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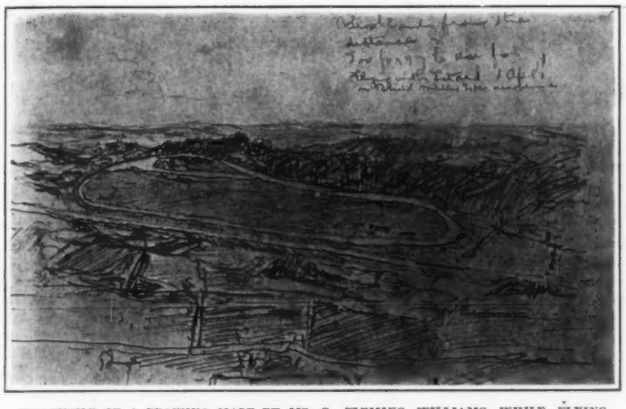
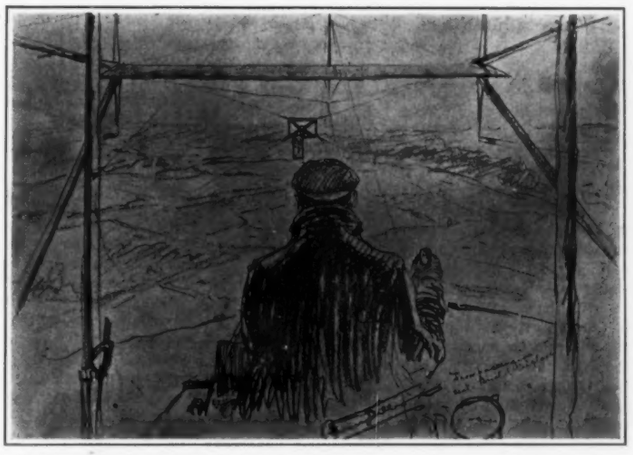
The Aeroplane Military Scout

It may as well be recognized at once that the aeroplane can never be seriously considered as a means of transportation on any extended scale. The present indications are that a single machine can never hope to carry more than two or three passengers. For the carriage of heavy freight it is altogether out of the question; although it is possible that it may have a field of usefulness in the post office and express service, for the transmission of important mail and light packages with the least possible delay.

Undoubtedly the greatest field of usefulness of the aeroplane will be in military operations; although even in this field its work will be of a limited character. Its small carrying capacity will prevent its being used on any extensive scale for the carrying and dropping of high explosives. The amount of explosive which it could take up would be so insignificant as to have no particular value for this purpose. The attack on fortifications, arsenals, dockyards, fortified camps, and cities by landing within them high-explosive shells, can only have any decisive effect upon the outcome of a war, if the high explosives can be thrown in enormous quantities. The dropping of a few isolated shells could work only a limited amount of damage, and unless they could be accurately aimed,



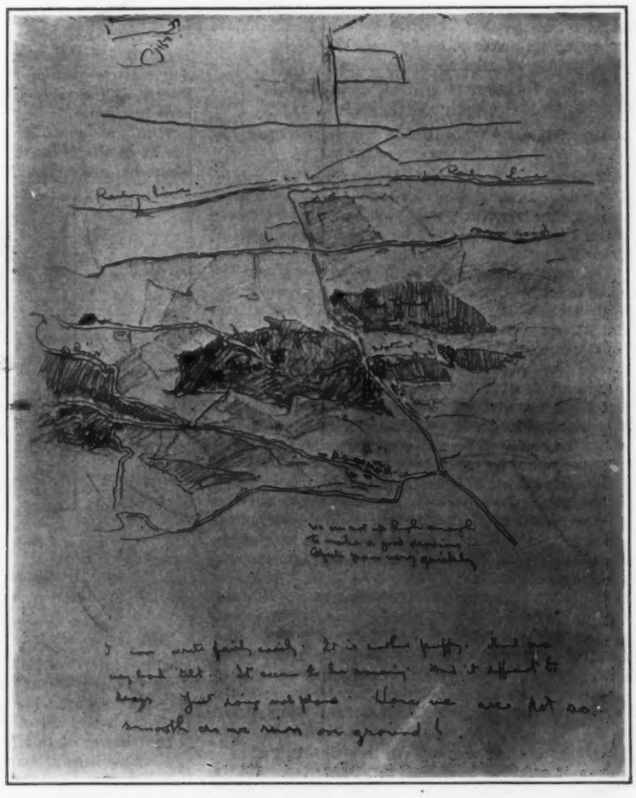
FAC-SIMILE OF A DRAWING MADE BY MR. C. FLEMING WILLIAMS WHILE FLYING ON A BIPLANE. THE SUBJECT IS THE MOTOR RACE TRACK AT BROOKLANDS, ENGLAND



A VIEW FROM THE PASSENGER'S SEAT, SHOWING THE PILOT AND THE COUNTRY IN FRONT

HOW SKETCHES WERE MADE IN MID-AIR BY MR. C. FLEMING WILLIAMS TO SHOW THE POSSIBILITIES OF THE MILITARY DRAFTSMAN

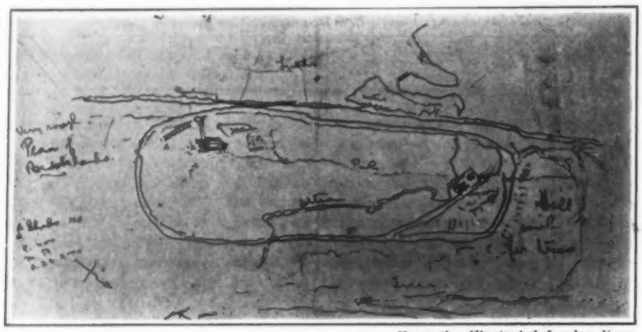
Drawings reproduced from the *Illustrated London News*.



A MILITARY PLAN SKETCHED BY MR. C. FLEMING WILLIAMS FROM A BIPLANE SHOWING THE POSSIBILITIES OF THE AVIATOR-SCOUT

THE MILITARY SCOUT AND HIS POSSIBILITIES

they would represent so much time and money thrown away. Experience in bombardments has proved this fact conclusively. It was only after the capture of 203-Meter Hill, outside Port Arthur, when the fire of the guns could be accurately directed, that the heavy mortar batteries were able to do any very effective work. Now to aim the one or two high-explosive shells which an aeroplane could carry so that they would unerringly hit some particular point below, would be a practical impossibility, for reasons which it is not necessary here to enter into.



From the *Illustrated London News.*

A ROUGH PLAN OF BROOKLANDS MADE BY MR. C. FLEMING WILLIAMS

Mr. Fleming Williams writes: "As we whiz around the racing track towards the hangars at a merry 45, a weird thing on wheels, shaped like a cigar, with a huddled figure where the hand ought to be, races past us as though we were stationery. A roar, a puff of air, slightly warm, a little discolored with blue smoke, and it disappears around the bend of the track."

The military aeroplane of the future will find its greatest field of usefulness in the important work of scouting. The military scout will carry two men; one to operate the machine, and the other to take photographs and make reconnaissance sketches of the country. The striking picture shown on the front page of this issue, is no mere dream of the enthusiast. It would be entirely possible for Wilbur Wright to take up with him an officer, rise to a height of 1,000 or 1,500 feet, sweep over 25 or 30 miles of an enemy's country, and secure a thoroughly accurate sketch of the lay of the land, the disposition and strength of the enemy, the various roads by which he might attack or be attacked, and all the other information which it would be the duty of the reconnoitering officer to secure. Because of the height at which the aeroplane would travel, and the uncertainty as to its speed and direction of flight, it would be an extremely difficult object to hit; and it would be possible for several shells of the small caliber which would be used in an attack to pass through the canvas of the aeroplane without impairing its stability.

Mechanical Handling of Materials*

By RICHARD DEVENS.

Manager Eastern Office of the Brown Hoisting Machinery Company, New York City.

WITHIN the last few years some of our railroad, industrial and steamship companies have begun to realize the important part mechanical transference plays in the quick and economical handling of material.

The most efficient advances have been made in the handling of bulk material, such as ore, coal and grain, while package freight, comprising boxes, barrels, bags and other packages, which make up the load of a freight car, or the cargo of a steamship, has just begun to receive serious consideration.

It is no doubt a fact that the proficiency in handling bulk material was due to the difficulties to be overcome in the transportation and handling of iron ore to the center of the iron industry.

I have reference to the iron ore that was discovered in the Lake Superior country.

The first problem was the transportation, and this was overcome in 1855 when the federal government completed its first system of locks at the falls of the Sault Saint Marie River at Sault Saint Marie, Michigan.

The second problem was the loading and unloading of the vessel. The loading was readily accomplished by the building of a long line of pockets on a dock, extending into the lake, and the equipping of each pocket with chutes. The pockets were of such height that the ore would flow from them over the chutes and into the vessel by gravity. The railroad cars, of the bottom dump type, were brought over the top of the pockets and dumped into them.

It is interesting to note that the method used in the first loading dock is the one on which all docks have been constructed since.

The unloading has been the most difficult to accomplish in a quick and economical manner.

The first vessels to carry iron ore were not constructed for the purpose, and while they carried some ore in the hold, most of it was carried on deck. When it was carried in the hold, it was hoisted to the deck by horse-power, and dumped into barrows; and then, like the deck cargo, wheeled ashore.

The next step was the substitution of a small hoisting engine for the horse-power.

This early method was in operation many years, and it was not until the dock managers were forced into it, by the great expense in carrying large storage on the dock, that any mechanical devices were attempted.

A cableway machine, built and erected at Cleveland, Ohio, in 1880, under Mr. Alex. E. Brown's design and supervision, was the first mechanical plant.

The next machines were of the bridge type.

The method of handling the iron ore, over either the cableway or bridge, was to fill iron buckets by hand in the hold of the vessel and then hoist them by the machine and dump them automatically into railway cars or storage. In the hold there were from twelve to fifteen shovellers to each machine, and there were two men on the machine, one an operator and the other a fireman.

Both of the above equipments were a great improvement over the early methods, and handled the iron ore in a satisfactory manner; yet they did not cut down the cost of the hand labor in filling the buckets in the hold. This was a very large part of the cost of unloading.

An automatic filling bucket had been worked successfully for a number of years in coal and similar soft material, but on account of the hard and lumpy nature of the early iron ores, it could not be operated in them.

With the use of the soft Messaba ores, interest in the automatic filling or grab bucket was renewed, and about ten years ago the first successful grab bucket machines were erected and operated at the Illinois Steel Company's plant at Chicago by the Hoover & Mason Company. This plant was designed to unload from the vessel direct into railway cars.

The success of this plant was the beginning of the present methods of unloading iron ore.

There have developed two types of grab bucket machines; one with the grab bucket suspended from wire ropes and the other with the grab bucket carried on a rigid arm.

The cost of filling the buckets by hand was about 13 to 15 cents per gross ton, and the cost of hoisting and dumping into railway cars or storage from 1½ to 2 cents per gross ton, making the total cost of unloading from 14½ to 17 cents.

With the grab bucket machines, this total cost has been reduced to from 1 to 2 cents per gross ton, depending on the distance the ore is carried from the vessel.

The hand-filled buckets were of about 1 ton capacity, as this size had been found to be the most practical for filling and handling in the hold.

With the grab bucket the size is only limited by the dimensions of the hatch and the shape of the vessel.

The first grab buckets for iron ore were of 5 tons capacity, but since then machines have been built to handle 7½, 10 and 15 tons.

Besides reducing the cost of unloading, the ability to handle in larger units has reduced the time; whereas with the hand-filled buckets, to unload a 6,000-ton vessel was a question of days, it is now only a question of hours.

The steamer "Morgan," of the Pittsburg Steamship Company, with a cargo of 11,319 tons of ore, was recently unloaded at Fairport in five hours and fifty-eight minutes. The work was done with six Brown Electric Unloaders.

These improvements have also increased the earning capacity of the vessel by making possible a greater number of trips during the season. This is shown by the following comparative statement for the years 1906 and 1910 showing the average stay at upper and lower ports of the vessels of the Pittsburg Steamship Company:

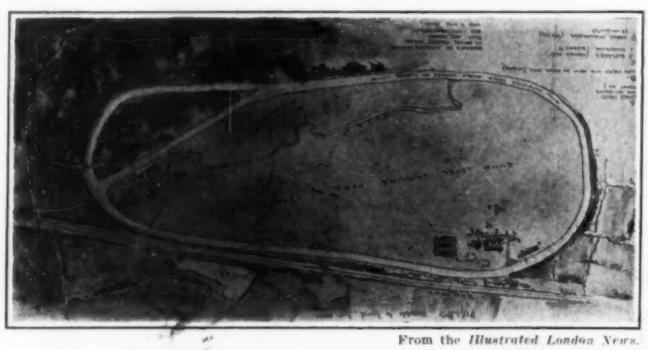
	Year 1906. Hr. Min.	Year 1910. Hr. Min.
Average stay in lower lake ports	36 15	22 22
Average stay in upper lake ports	22 25	12 22
Average time spent in port receiving and discharging cargoes	58 38	34 44
	Gross Tons.	Gross Tons.
Average cargo carried	5,954	6,634
Largest cargo carried	13,333	13,296
	In 70 Min	In 45 Min.
Fastest loading record	9,277	9,788
	Tons per Hour.	Tons per Hour.
Rate of fastest loading record	7,280	13,051

In the foregoing I have outlined the development of handling bulk material, using iron ore as an example. The handling of package freight has not been brought to the same degree of perfection.

In many manufacturing concerns, mechanical devices have been installed to reduce the cost of handling, and to hasten the transportation of their products, but for quick and economical handling of freight at shipping docks and railway terminals, little has been done in this country.

In Europe greater advances have been made, due largely to the encouragement given by the city or government, which frequently itself equips the docks.

At Hamburg, Antwerp, Bremerhaven, Glasgow, London, Manchester, Havre and many other ports are found mechanical appliances, each to meet the local requirements, but all aiming to reduce the number of handlings and the cost of the same.



From the *Illustrated London News.*

THE ROUGH SKETCH OF BROOKLANDS ELABORATED AFTER REACHING THE GROUND

Mr. Fleming Williams, the artist, writes: "Should a general be doubtful as to the best road to choose to reach a certain spot, an aviator could, in a few minutes, ascend and not only see the best way, but sketch a map of it or write a report. Should the position of an enemy be doubtful, the aviator could easily locate tents or moving columns from a height and distance that would render him practically immune from gun fire."

In England at the freight stations and warehouses the practice is to install jib cranes, so arranged that they can serve all the floor space from car or wagon.

In this country many of the railroads have put in hand cranes of the pillar or bridge type, for handling freight from cars to wagons, or *vice versa*, but they are mostly for heavy lifts, and are slow in operation, and cover only a limited area.

Some of the railroads have put in electric cranes in their freight yards and water terminals; as for example, the Pennsylvania Railroad Company on its

* Presented before the Congress of Technology at the Fifteenth Anniversary of the granting of the Charter of the Massachusetts Institute of Technology.

Greenville docks, the New York Central & Hudson River Railroad Company at Port Morris, the Philadelphia & Reading Railroad Company at Port Richmond, and the Central Railroad of New Jersey at Communipaw.

Many of the railroads are coaling their locomotives at greatly reduced cost and time by mechanical appliances, but the question of handling their package freight at terminals is still open.

Most managers have known that there is a great loss of time in transferring freight at terminal and intermediate points, but few seem to realize the high costs that this involves.

Perhaps the most complex movements in the handling of package freight are at the large steamship piers due to the great carrying capacity of the large vessels, the many consignees, each having his allotted space, and the limited floor area that has to be cleared quickly to make room for the next vessel. The larger railroad terminals also have their many consignees, but the floor area is not so restricted.

The placing of the packages in the proper space is done by the hand truck. A sling load from the vessel or a railway car may contain packages for several consignees. The truckman cannot wait to sort as he receives them, so must load his truck with them as they come. This means a long travel to get the packages to their alloted space. In order to tier them, several more handlings are necessary. All this leads to congestion and increasing cost per ton.

This is further effected by the rise in the cost of labor, materials, rent and larger terminals.

Each terminal is a problem in itself, as is each manufacturing establishment, so that it is necessary to make a careful study of the conditions to be met before any mechanical method can be proposed.

In the last thirty years there has been a steady increase in the capital invested in manufactures, which means an increase of tonnage of all kinds of package freight carried by the steamship and railroad companies. To meet this, the railroads have increased their rolling stock and either enlarged their terminals or built more. In large cities this has been at great cost for land and buildings. The method of handling the freight has remained the same.

At a terminal there are two kinds of freight—outbound and inbound. The outbound is transferred from wagons into the outbound freight house and thence to the railway cars or directly from the wagons to the cars.

The inbound is *vice versa*.

All the above movements, except between wagons and cars, involve the sorting and distributing of each package to its designated space. It is also necessary to transfer cars from one freight house to the other, as the use of the hand truck necessitates bringing the cars to the freight.

A mechanical equipment to be satisfactory must be able to distribute the outbound and inbound freight simultaneously; there should be no rehandling, and every square foot of floor space should be served with a single handling.

All motions of lifting and conveying should be done by power. The machinery should be designed to give the greatest lift required and to transfer to any reasonable distance, and then tier or lower into cars.

Continuous operation should be sought for to avoid delay.

No part of the transference should be along the floor, and the equipment should not take up any floor space that can be used for other purposes.

All movements of the mechanical equipment should allow of the assorting and distributing according to classification and allotted space readily and quickly.

There must be reserve capacity to prevent congestion in case of extra demands.

The justification for the investment of the mechanical installation lies in the reduction of cost and the saving of time in handling.

The expense should be in proportion to the size of the terminal.

There are many companies in this country engaged in the manufacture of hoisting and conveying machinery. While perhaps no one makes all the necessary appliances, yet a combination of their product could be used to fill the special requirements of each terminal point.

Fully to cover the floor space and obtain all the different requirements for the satisfactory handling of the package freight, three units or different types of conveying machinery are necessary. These are the single rail electric trolley, the bridge traveler and the cross traveler. The electric trolley is the actual load carrying part of the equipment, the single rail, bridge traveler and cross traveler furnishing a combination of loop track system on which the trolley can reach any part of the area to be covered. All movements should be so regulated that there will be no interference, and many trolleys can be in operation following one another. Each trolley can draw a number of trailer trolleys, so that many packages can be hoisted and transported under the control of one man.

This arrangement allows many loads to be transported in close sequence simultaneously, and with maximum hoisting and traversing speeds, gives the greatest range and capacity at a minimum of labor and maintenance.

At some freight terminals it may be necessary to have, in combination with the above mechanical conveyors, motor trucks on the surface; in others, belt conveyors.

There is no doubt that some such scheme as outlined above, when properly carried out to meet the special requirements at any terminal, would materially reduce the time and cost involved in the present method. This has already been exemplified in the handling of bulk material.

Considering the special attention now being given this question by several engineers and the interest shown by many steamship and railroad managers, it can be safely stated that within the next few years great changes and developments will be accomplished.

Electrical and Chemical Effect of Ultra-violet Rays

The Hertz Effect

HERTZ discovered, in 1887, that a polished metal plate, charged with negative electricity, was quickly discharged by the impact of ultra-violet rays. Almost all that is yet known concerning this remarkable photo-electric phenomenon, which has been called the Hertz effect, was soon discovered by Hertz and other skilful experimenters, and no satisfying explanation of the phenomenon has been furnished by the numerous researches that have since been made.

The Hertz effect is easily produced. The spectrum of an electric arc is thrown, by means of a slit *S*, a quartz lens *L* and a quartz prism *P*, upon a polished plate of metal *M*, which has been substituted for the ball of a gold-leaf electroscope *E*, and has been charged negatively, so that the leaves *ff* diverge widely. Any desired portion of the spectrum can thus be allowed to fall on the metal plate, the remainder being cut off by screens attached to the electroscope. The electrical condition of the plate is not affected by the rays of the visible spectrum, but the gold-leaves rapidly fall, showing loss of electric charge, when ultra-violet rays strike the plate. No similar effect is produced when the plate is positively electrified.

Hertz was led to the discovery of this curious effect by observing that the discharge between the polished metal balls of an electrical apparatus with which he was working was facilitated by the production of electric sparks in their vicinity. It would be interesting, but it would require too much space, says a writer in *La Nature*, to follow the long course of experiment and deduction by which Hertz successively eliminated every other possible cause and finally traced the last-mentioned phenomenon to the influence of the ultra-violet rays emitted by the spark.

The Hertz effect cannot be reproduced indefinitely with the same plate without repolishing. After a time the ultra-violet rays fail to dissipate the negative electric charge. The metal is then said to be "fatigued," but its sensitiveness to ultra-violet rays can be restored by polishing it with emery paper. Various ingenious explanations of this mysterious phenomenon of photo-electric fatigue have been given, but none of them is satisfactory. The different metals vary considerably in their photo-electric properties. Zinc and aluminium exhibit the Hertz effect very strongly, while copper and silver are much less sensitive to ultra-violet rays. In general, the photo-electric order of the metals agrees closely with the electro-chemical order, the most strongly electro-positive metals being the most sensitive to ultra-violet radiation.

The chemical effects of ultra-violet rays have, until recently, been observed only incidentally, in connection with other researches. In this way an apparent formation of ozone in air and of hydrogen peroxide in water was noted, but even these simple effects have

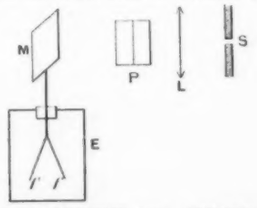


FIG. 1.—ARRANGEMENT OF APPARATUS FOR PRODUCING THE HERTZ EFFECT

been the subject of controversy. Last year some direct experiments were made which appear to prove that ultra-violet rays possess great chemical powers. By their agency Berthelot and Gaudechon have transformed cyanogen into paracyanogen, and oxygen into ozone; polymerized acetylene and ethylene; converted a mixture of ammonia and oxygen into nitrogen and water; and oxidized acetylene to carbon monoxide, carbon dioxide and formic acid.

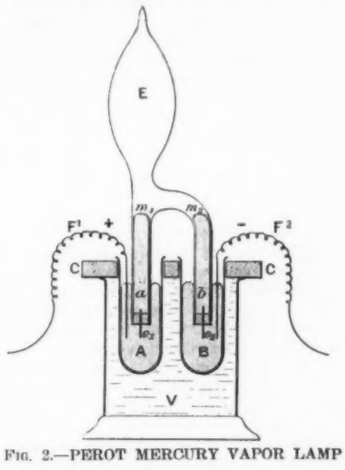


FIG. 2.—PEROT MERCURY VAPOR LAMP

The ultra-violet rays are still enveloped in mystery, and many years may elapse before their effects are thoroughly known and explained. Researches in this field promise to contribute much toward the formation of a satisfactory theory of the constitution of matter, which is one of the most audacious enterprises of modern science.

Ultra-violet rays are produced by the electric arc, and their intensity is increased by employing carbons with zinc or aluminium cores. In experiments which require the isolation of the source from the surrounding medium, a mercury vapor lamp should be employed. Prof. Pérot has devised a lamp of this type, which is easily managed, of small dimensions, and much less expensive than the lamps generally employed. The quartz vessel (Fig. 2) in which the light is generated has the general shape of the small letter "h," consisting of two vertical tubes *a b*, and an olive-shaped bulb *E* placed directly over the tube *a*. The tubes are filled to the level with mercury, and stand in two wide, open-mouthed glass tubes *AB*, which also contain mercury. Electrical connection between the mercury in the inner and outer tubes is maintained by two platinum wires e_1e_2, which traverse the closed ends of the quartz tubes. The mercury in the glass tubes *AB* is connected with a source of current by the wires F_1F_2, the tube *A* being connected to the positive pole. The glass tubes are suspended from the cover *CC* of a vessel *V*, which is filled with water for the purpose of preventing overheating. When the circuit is closed an arc forms spontaneously between the anode meniscus m_1, and the cathode meniscus m_2. The tendency of particles of mercury to travel with the current from the anode to the cathode is counteracted in the Pérot lamp by the fact that all of the mercury which rises as vapor from both tubes and is condensed on the walls of the bulb *E* falls back into the anode tube *a*. Experience shows that the mercury remains constantly at the same level in both tubes, with a current of 30 volts and 2 or 3 amperes. In these conditions the lamp furnishes a perfectly steady constant light.

A 60-watt tungsten filament lamp will illuminate very satisfactorily a fairly large room, yet its filament, if crushed to powder, would make a cube of less than one-twentieth of an inch on each side. Nevertheless, few substances are subjected to such severe treatment as the bit of matter that composes the filament of an incandescent lamp, and the number of materials which can be used for that purpose is consequently very limited.

The German Antarctic Expedition

Its Personnel and Its Equipment

THE German Antarctic Expedition will start in the early part of May, 1911. Its principal object is to explore the interior of the Antarctic Continent and to establish a connection between its eastern and western parts. The expedition will proceed from Hamburg to Buenos Aires and thence to the island of South Georgia, where it will refill its bunkers from a store of coal which has been sent ahead, after which it will push on southward to Weddell Sea. It is the intention to search for Coats Land, discovered by Bruce in 1904, on the eastern side of Weddell Sea, to follow the coast as far southward as possible and establish a base and scientific station, which will be maintained for at least one year and will serve as the point of departure for expeditions by sledge into the interior. For this purpose a detachment of eleven or twelve men has been specially assigned.

A detailed account of the scientific program of the expedition is given in a memorial circular, from which we quote the following information as reproduced in *Illustrirte Zeitung*. The honorary chief of the expedition is the venerable Prince Regent Luitpold of Bavaria. The personel consists of thirty-five men. The actual leader of the expedition is Dr. Wilhelm Filchner, a Bavarian officer, well known through his explorations in China and Tibet, who has been assigned to the command of the expedition by the Prussian General Staff. The second in command is Dr. Seelheim, the geographer of the expedition. The meteorological observations will be conducted by Dr. Barkow of the Royal Meteorological Institute at Potsdam; the oceanographer is Dr. Brennecke of the Hamburg Naval Observatory, who occupied the same position in the "Planet" Expedition to the South Sea; the geological work is in the hands of Dr. Heim of Heidelberg, and the physicians are Dr. Kohl of Munich and Dr. Wachter of Vienna, both of whom are trained alpinists and snow shoe experts. Dr. Felix Koenig has been added to the party because of his expert knowledge of sledging. Prof. Lohmann will accompany the expedition from Kiel to Buenos Aires as biologist. The astronomical and magnetic observations will be conducted by Dr. Przybyllok of the Potsdam Geodetic Institute. Herr Neuberger, an expert automobile machinist, will look after the motor vehicles. The nautical command is in the hands of Capt. Vahsel of the Hamburg-American Line, who was second officer of the "Gauss" in the first German Antarctic Expedition, and who commanded the "Peiho" in the recent German South Sea Expedition. The first officer is Herr Lorenzen, who occupied the same position on the "Peiho." The second officer is Herr Mueller, of the North German Lloyd, who has long been navigator on the cable steamer "Stephan." The third officer, Herr Slosarczyk, has prepared himself for his work as wireless operator of the expedition by similar work on the transatlantic liner "Patricia."

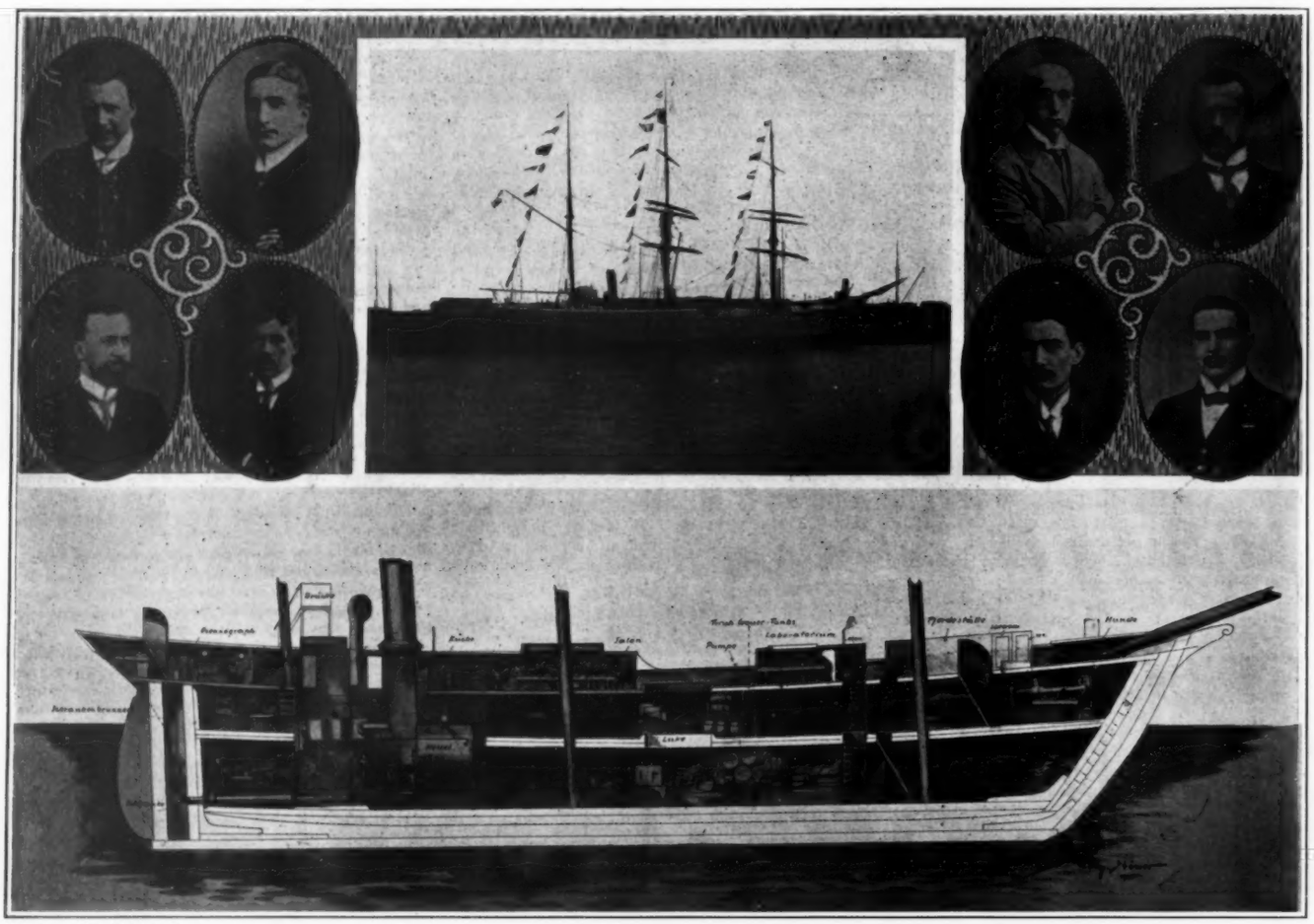
The chief engineer is Herr Heyneck, of the Hamburg-American Line. Several of the best men of the "Gauss" expedition have been secured, including the cook Klick, the carpenter and diver Heinrich, the steward Besenbrock, and the preparator Noack.

The outfitting of the expedition falls naturally into three parts: the ship, the provisioning and the means of land transport. All the experience accumulated in former polar expeditions has been utilized in the preparations, and Dr. Filchner made a special expedition from Spitzbergen last year in which he accumulated much valuable experience and formed the acquaintance of several scientific men of the expedition, who accompanied him.

The expedition is provisioned for three and one-half years, and carries more than 200 tons of food stuffs. Automobiles of peculiar construction which have been very successfully employed for drawing sledges in extensive experiments in Norway and the Bavarian mountains will be carried for that purpose. Capt. Scott will employ similar vehicles in the English Antarctic Expedition which is now fitting out. In addition, dogs will be carried, and also ponies, which Shackleton found very useful for drawing sledges. The sledges carried by the expedition are of the type used so successfully by Nansen. Most of them are about ten feet long, two feet wide and very low. The dogs were obtained from Greenland, the ponies from Eastern Asia.

The ship, the "Deutschland," was purchased in Norway last autumn. It is a whaler, and has proved its stanchness in ice. It was built in 1905 of spruce, oak and pitch pine, with ice breakers and an ice shield of "greenheart." It is bark rigged, and has an auxiliary engine of 300 horse-power, which, with favorable weather and a daily consumption of five tons of coal, can drive it at the rate of seven knots. Under sail the ship can make nine or ten knots with a favoring wind. The gross tonnage capacity was originally 527 tons, but alterations have been made which increase the capacity by more than 100 tons. The ready-built houses, sledges and building timber will be stowed on deck on leaving Buenos Aires. The cabins for the officers, scientists, cook and steward, the kitchen and pantry, and a large and a small saloon are located in a well protected deck house, occupying the after half of the ship. Each officer and scientist has a separate cabin. On the forward deck is a large laboratory, flanked on each side by stalls for ten ponies. Between decks are the men's quarters and lavatory. The dogs are quartered under the forward deck. The ship has been equipped with an electric plant, and all its parts will be lighted by electricity, except in case of a shortage of coal. The dynamo will also serve to operate the wireless transmitter. Two tanks of 11 tons capacity and two of ¾ ton capacity will contain the supply of drinking and boiler water. The vessel is provided with a device for raising the propeller. Three propellers are carried, two of nickel steel and one of iron. The boats include two whale boats, two large lifeboats and a seven-horse-power motor boat.

The total cost of the expedition is estimated at $350,000. To defray this cost the governments of most of the German States have authorized lotteries, the guaranteed net proceeds of which will be about $200,000. Large subscriptions have also been received from various persons. Nevertheless, additional funds are required to carry out the expedition to success, and it is to be hoped that the appeal issued by the committee will meet with a generous response.



From the *Illustrirte Zeitung.*

PHOTOGRAPH AND LONGITUDINAL SECTION OF THE "DEUTSCHLAND" AND PORTRAITS OF THE LEADING MEMBERS OF THE GERMAN ANTARTIC EXPEDITION

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A Modern X-Ray Laboratory

The Interrupter or "Break"

By Reginald Morton, M. D.

ONE of the most important elements in the modern X-ray equipment is the interrupter or "break," as it is generally called. As its name indicates, its function is to interrupt or break the flow of current through the primary coil of the inductorium. A sudden interruption is essential for the working of the coil, and the more sudden and complete it is the

FIG. 1. AN X-RAY CABLE TESTING OUTFIT

better is the discharge from the coil. A review of some of the principal types of "breaks" in use at the present day is given by Reginald Morton, M. D.,

Up to the time of Roentgen's discovery, breaks were of a simple and not very efficient form; they were only used in circuit with batteries of low voltage, and as the induction coils were as a rule small in size and giving short spark length they answered well enough.

The demand for greater discharges to excite heavier and stronger tubes soon made it evident that the interrupter would have to be modified, especially as it was desired to make use of the comparatively high pressure currents from the street mains. The platinum hammer break (see Fig. 2) was one of the first, and though it is seldom used now for heavy work, and mostly on portable apparatus, in its most modern form it can be made to give very good results. It requires care in adjustment and manipulation, but is practically the only kind that can be used in military service in the field.

A disadvantage of this form is the flashing that takes place between the platinum points every time the current is broken; this is troublesome when it is desired to make use of the fluorescent screen in a dark room.

It was found that when the break was so modified that one of the points was replaced by a dish of mercury, the spark from the coil was intensified. In one of the earliest types a copper wire was made to dip in and out of the mercury by the action of a small electric motor, and a number of interrupters

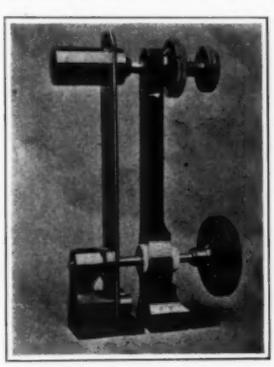


FIG. 2. A PLATINUM BREAK

of this kind are in use, for X-ray treatment especially (see Fig. 4).

Following on this we have the mercury jet breaks, which were a great improvement, in that they gave a much higher rate of interruption for the same quality of discharge from the coil. In these a small jet of mercury is made to impinge upon a copper blade or blades. It is immaterial whether the jet revolves or whether the copper teeth revolve around the jet, the result is the same. The mechanism is inclosed in a glass or iron vessel, which contains a quantity of mercury at the bottom, and is then filled up with spirit or paraffin oil. The break thus taking place under the surface of the fluid is all the more sudden and complete, and this type of mercury break has been, and is, very popular. The great disadvantage is the large quantity of mercury required (20 to 30 pounds in some) and the rapidity with which the latter becomes emulsified and useless for the time being. Most of the mercury can be recovered, but the process is very messy. (See Fig. 3.)

Owing to this difficulty of cleaning, efforts were made to find some gaseous medium to replace the liquid in common use, and it was found that ordinary house gas was all that could be desired; it may be said that any mercury break designed for the use of liquid will work equally well, or even better, if the gas is used instead. The case has, of course, to be made tightly-fitting, so as not to allow free escape of the gas. Used in this way the mercury does not become emulsified, only a small quantity is required, and the small amount of black mercury compound that gradually forms need only be removed at long intervals.

The most recent development of the mercury break is a more or less radical departure from the jet type we have been considering, but the change is a very important one, and the system upon which they work is one that is likely to prevail. The principle involved is an old one, though its application to interrupters is quite new. It is well known that if we fill a hollow sphere with liquids of different densities, and then

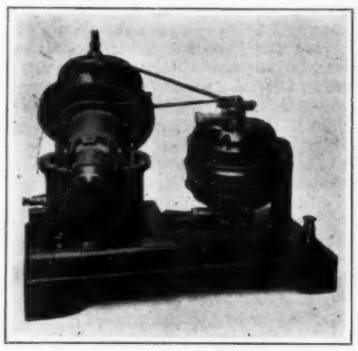


FIG. 3. A JET-BREAK

rotate the sphere rapidly, the various liquids will tend to arrange themselves around the equator of the sphere with the heaviest liquid against the wall and the lightest liquid nearest the center of rotation. Applying this principle to an interrupter, the hollow space is flattened at the poles and the equator is bulged out. This form is found to give the best results, as might be supposed. (See Fig. 5.) Into this jar is placed some mercury and paraffin oil, and the whole is mounted upon the end of the shaft of an electric motor, which is placed vertically. As the latter is set in motion the jar turns with it, and the mercury, by virtue of its greater weight, at once takes up its position at the widest part. Its rate of rotation is a little less than that of the jar, which is made of cast iron, both for its strength and its resistance to the action of mercury. There are several forms of interrupter working on this principle, but the above arrangement forms the basis of them all. In one of them, a fiber disk with a metal segment, and about the size of a five-shilling piece, is mounted so that its edge engages the whirling band of mercury. This causes the disk to rotate rapidly, and as the metal segment touches the mercury the circuit is completed, to be suddenly and completely broken when it leaves.

When we consider the remarkable property of the X-rays in readily passing through substances that are quite opaque to ordinary light it would seem that they ought to be of the greatest use under many and diverse conditions. In the early days of their discovery many extravagant predictions were made as to their probable value and these were treated more or less seriously. As a matter of fact, if we take away their application in medical and surgical work, so little remains that the demand for the necessary apparatus would be too small to be worthy of the serious attention of any manufacturer, except in the fulfillment of a special order.

It will be thus easily understood how difficult it is, when treating of the uses of the X-rays, to avoid reference to medical matters. Their limited use in other directions is due to several causes, and the chief one is that the X-ray image is a silhouette and not a photograph, as it is sometimes erroneously termed. The property of arresting the passage of

FIG. 4. A DIPPER BREAK

the X-rays and thus casting a shadow is purely a question of the atomic weight of the elements that make up any substance. Speaking generally, substances of vegetable and animal origin, except the bones, are very transparent. With the exception of aluminium, all the metals in common use are more or less uniformly opaque. Calcium having an intermediate atomic weight is semi-transparent, and as lime salts enter very largely into the structure of most living organisms, the X-rays are very valuable in studying their normal structure as well as tracing departures from the normal, whether from disease or accident. Any inequalities in thickness are registered on the screen or plate, and so accurately is this done under favorable conditions that the details of structure can often be made out; a good radiograph of the hand or foot shows this very well.

Some very interesting discoveries have been made in this way regarding the internal structure of shells, and the rays have been used in examining oysters for the presence of pearls. If no pearls are present the oyster is returned to the sea, which is presumably an advantage to the oyster. In a like manner electrical cables are examined (see Fig. 1), both for the continuity of the conductor and to see that it maintains its proper relation to the other members of the system. The modern electric cable is in many instances a very highly specialized structure, that has to stand very severe strains both mechanical and electrical, and, as an apparently small fault may give rise to very serious trouble, the final inspection has to be carried out with the greatest care before it is passed as fit for service.

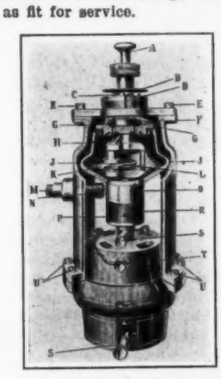


FIG. 5. SECTION THROUGH ROTATING DISK BREAK

With regard to the medical and surgical uses of the X-rays, most people are inclined to think that the examination of fractures and the detection of foreign bodies within the human organism constitute the main field of their usefulness. These are, of course, very important applications, and ones that count for much in hospital practice particularly, but they do not by any means constitute the whole. An ordinary simple fracture occurring in the shaft of a long bone such as in the middle of the upper arm,

can be dealt with quite satisfactorily, whether examined by the X-rays or not; but the surgeon who attempts to deal with a fracture close to, or involving a joint, without having it properly examined by this method, takes a risk to his patient, as well as to his own reputation, that is not justifiable. In an instance of this kind an injured wrist was declared to be a severe sprain and treated as such. Fortunately the patient decided to come to the hospital, where it was X-rayed as a matter of routine. This showed that the bone was not only broken in at least three fragments, but that one of the lines of fracture entered the wrist joint. The fact that there was no displacement of the fragments led to the erroneous diagnosis being made, and had this been treated in the ordinary way a stiff wrist joint would have resulted almost certainly.

In the early days of the X-rays their use was almost entirely confined to strictly surgical cases; nowadays the method is used almost as much for the investigation of medical cases, such as disease of the respiratory organs, the heart and great blood vessels, tumors, and obstructions in the digestive system. The last-mentioned application is a comparatively recent development, and one of great interest. The method consists of giving jelly or other food containing a large amount of a bismuth compound, which is quite harmless. The bismuth being opaque to the X-rays, the progress of the food can be watched in its advance along the digestive canal, and at times the information gained is very valuable. There is a great danger, however, in misinterpreting the appearances, because similar shadows may be made by very different conditions; in no instance is the opinion of an expert more necessary than in this.

By means of very powerful apparatus more or less instantaneous radiographs can be made of the heart when the X-ray tube is placed no less than two meters from the plate. Owing to the great distance of the tube, the size of the shadow of the heart is very nearly the same as that of the heart itself, and it is the best method at our disposal for accurately determining the dimensions of that organ. Changes in these dimensions can be detected by making examinations at intervals. This by no means exhausts the list of applications of the X-rays in the diagnosis of disorders of mankind, but enough has been said to show how much progress has been made, and the science is by no means at a standstill. Improvements in methods and in personal skill are being introduced every day, and scarcely a month passes that does not give us something new in the way of improved appliances.

It was comparatively soon after the discovery of the X-rays that some investigators began to employ the radiation for purposes of treatment. They were led to do this from the good results that were being obtained with the ultra-violet rays, and from the fact that many X-ray workers had begun to suffer from a form of dermatitis, which was rightly attributed to the influence of the X-rays themselves. It was at this stage that the foundations were laid for the immense amount of suffering that has been endured by many of the pioneers of X-ray work, many of whom still continue to suffer in one way or other, in spite of the fact that they have taken every possible precaution since the first attack of the dermatitis. The danger from these rays is only incurred by those who are working with them more or less continuously; there is not the slightest danger to any one who undergoes an examination or a course of treatment by the X-rays, so long as the work is done by one who is a recognized expert in such matters.

It may be taken as an axiom that any agent that is capable of doing so much harm as this can also be made to do a great deal of good, if only its powers are properly controlled and directed into the right channels. The great trouble in administering these rays therapeutically was that of knowing how large or how small a dose was being given, and even at the present time the methods at our disposal are not anything like so simple and scientific as that of giving ordinary drugs. We have no satisfactory method of ascertaining the exact strength of radiation the patient is getting at any given moment; our methods will only tell us how much has been given, and that rather crudely. The means mostly employed are sufficiently accurate in the hands of one who has had a considerable experience of the work, and who has become more or less familiar with the vagaries of the X-ray tube. The day is not yet that the novice can dip into this work without running considerable risk.

When the platino-cyanide of barium is exposed for a certain time to the influence of the X-rays it turns from its usual greenish-yellow tint to that of a light orange. This material is spread upon stiff paper and cut into small circular pastilles. The X-ray tube is inclosed in a ray-proof shield, from which the rays can escape only by an opening made for the purpose, the size and shape of which can be altered to suit any ordinary conditions. The pastille is held in a clip exactly half the distance between the source of the rays and the area to be treated, and is so arranged that it can be removed for examination from time to time. With each set of pastilles is supplies a standard tint, to which the pastille must change before the ordinary full dose is given. This is, in outline, the method in use at the present time by the majority of radiologists. It is, admittedly, a crude one when judged by other standards of measurement, but in the hands of the expert it gives very good results.

With regard to the conditions that are benefited by this form of treatment, it may be said that the more superficial is the disorder the more likely is it to be favorably influenced; this is only another way of saying that the method finds its greatest field of usefulness in the treatment of the diseases of the skin, and the results that have been obtained are at times quite remarkable. It is a very fortunate thing that it is among those conditions that are, as a rule, very resistent to all ordinary methods of treatment, that some of the greatest successes have been made.

Before closing this article it may be of interest to indulge in a little speculation as regards future developments. While we have seen that improvements in the electrical appliances have been going on from the very beginning, and show little sign of any falling off in this gradual but steady improvement, the X-ray tube itself has undergone no radical change since the invention of the focus tube by Prof. Herbert Jackson.

It is quite true that the X-ray tube of the present day is a great improvement on the original Jackson tube; it is larger in size, more steady in action, and more capable of withstanding the various and severe stresses to which it is subjected, and is also provided with a means of regulating its vacuum; but it remains in principle as it always was, and great as its improvement has been it has not kept pace with the development of the electrical side of the X-ray equipment. Any modern coil can completely wreck any X-ray tube in a few seconds if desired. Our greatest want now is a tube that is steady in action and in vacuum, that will give out a certain quality of radiation as required, and continue to give this no matter how great power is applied to it within the limit of reasonable requirements. With a view of meeting some of the conditions, it has been suggested to make the bulbs of quartz instead of glass, but so far no one seems to have attacked the problem seriously. Quartz is much more transparent to the X-rays than any form of glass, it is independent of any changes of temperature, and will stand any amount of rough usage within reasonable limits. It certainly should be well worth giving a thorough trial, if only for the advantages already mentioned. But even with these advantages it could not be said that the X-ray tube was in the nature of a perfectly satisfactory instrument. In the present state of our knowledge it is very difficult to see how the X-ray tube can be radically improved upon. We can only wait patiently; and for all we know some means of getting our X-rays may be discovered that is much more simple and reliable, and entirely different from the methods we use at present.

The Past and Present Geographical Distribution of the Iron Industry of the United States

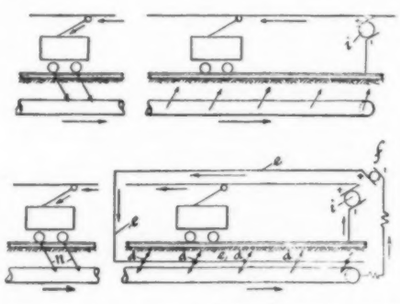
IN his address on "Geology and Economics," speaking before the New York Academy of Sciences, Prof. J. A. Kemp referred as follows to the geographical distribution of iron producing centers, and the changes which have taken place in their relative importance:

"The iron industry in the United States took its rise in the colonies along the Atlantic seaboard—and at the outset was based upon the magnetic ores and brown hematites there occurring. For one hundred and fifty years its growth was slow. In the decade of the forties and fifties of the past century it had spread to the Adirondacks and in the fifties began its development in the Lake Superior region. Not until after the close of the civil war and the resumption of peaceful activities did this great industry manifest its possibilities. With improved facilities of navigation which placed Lake Superior in easy communication with the coal-producing States of Pennsylvania and Ohio, the iron-ore-producing States of Michigan, Wisconsin, and later Minnesota, came rapidly into prominence. In somewhat slower growth Alabama, during the seventies and eighties gathered headway. At present four-fifths of our ore supply comes from the three Lake Superior States, and three out of the four-fifths from Minnesota alone. Alabama, Tennessee and Georgia together yield one-tenth and the remaining tenth is divided among a dozen or more other States, of which New York is the leader. Since 1880 the total has increased about seven-fold and Pennsylvania, then the source of about one-quarter the supply, now yields approximately one and one-half per cent. Minnesota, now the great source of ore, only entered the lists in 1884, and only began to utilize its present great mines about ten years later.

"Thus in the brief course of thirty years there have been very great rearrangements not only in geographical sources of supply, but still more in actual amount of output. In normal, prosperous years the annual production is somewhat more than fifty million tons of ore."

Protection of Underground Pipes from Electric Currents

GAS pipes and water pipes, laid near electric railway tracks, are frequently corroded by the action of stray earth currents. If the parts attacked are protected by a coat of tar, the mischief is simply shifted to the adjacent unprotected portions. The damage is done at the places where the positive current flows



PROTECTION OF UNDERGROUND PIPES FROM ELECTRIC CURRENTS

from the pipe to the earth because here oxygen is set free, while in places where the positive current flows from the earth to the pipe the metal is protected by an evolution of hydrogen. The arrows in the upper diagram of the accompanying illustration show the course of the current, generated by the dynamo *i*, flowing through an overhead trolley wire and a number of cars to the rails and leaking to the water pipe beneath. The pipe is corroded only in the right hand portion, where the positive current flows out of it. According to a note in *Prometheus* a German railway manager has succeeded in protecting such pipes by superimposing on the injurious current, a current flowing in the opposite direction.

The lower diagram shows how this result is accomplished. A second overhead wire *e* is stretched parallel to the trolley wire and is supplied by the dynamo *f*, with a current flowing in the same direction as the working current. The distant end of this wire is connected with a return wire *d* which is buried near the pipe and rails. The negative pole of the dynamo, however, is connected, not with the return wire, but with the pipe. Hence positive current flows from the return wire *d* through the earth to the right-hand part of the pipe, neutralizing the injurious current flowing from the pipe to the rails. This device has given satisfactory results during fifteen months' service.

Waterproofing Fabrics

THE French army is interested in a new method for waterproofing fabrics which is claimed to be superior to usual processes. English manufacturers have been in the lead in bringing out waterproof fabrics for many years past. Besides rubber, for fabrics, we have the use of insoluble gelatine, boiled linseed oil, shellac, metallic soaps and others, which have had more or less success. It appears that the best product for waterproofing is acetate of aluminum, and when applied to the fabric it can be made to form alumina in a gelatinous state and volatile acetic acid. When such fabric is dried it is waterproof, but has not the objectionable feature of rubber and other material, as it allows the air to circulate through it. The fabric is also quite supple, and this is especially necessary so that clothing can be made of it. As the French army department is looking for the best method of waterproofing which can be used for military cloaks as well as for tents, some experiments were made, and it was found that the above process is the best, according to the opinion of the best authorities. This is especially true now that acetate of alumina solution can be found on the market and does not need to be prepared specially. M. Balland recommends a bath of one part acetate (7 deg. B.) and forty parts water. Fabrics are soaked in it for twenty-four hours, and are then dried in the air. This method is being used in the army headquarters at present.

Fire and Burglar-Proof Safes.—I.*

Recent Advances in the Construction

By E. E. Watson

IN order to place before you the recent advances in the construction of fire and burglar-proof safes, it is necessary to cover a brief history of the industry from its actual beginning in the early part of the nineteenth century down to the present time.

Practically speaking, the more recent advances have had to do principally with refinements in mechanical processes, the development of factory organization and the perfection of elements of design that were conceived long before the means were at hand for their proper realization.

The development of any industry is in a large measure dependent upon the activity in other related industries, and the progress in the one must mean a general forward movement on the part of all.

The development of the art of building safes for the protection of valuables is interwoven so closely with that of the art of lock building that the two subjects necessarily must be treated together.

It is a fact that is apparent to anyone who gives consideration to the subject, that a safe, however secure from the standpoint of construction, would be useless without an opening giving free access to its interior, and that opening guarded by a lock at least as secure in point of design and construction as the safe itself.

The conclusion must be drawn from this that safe building, in point of relative security, could only keep pace with the development and with the design and construction of locks. The history, therefore, of the development of the safe building art is in reality, first, the history of the development of locks.

Locks, as we know them to-day, and as they have been known ever since they were first used, consist primarily of a bolt and a key for operating the bolt, and some means interposed between the key and the bolt to render the operation of the bolt either more or less difficult or impossible without the use of the proper key.

The means employed for housing the working mechanism of the lock, and for applying it to the protected structure, are of little importance in this consideration. All of the different locks possess these features. They may be divided into several general classes.

First, not only in point of simplicity, but naturally also in point of historical origin, is the latch lock, in which there is a bolt pivoted on a fixed point and raised by some sort of a key.

Locks were later rendered more secure by the introduction of the warded type in which the introduction of the key into the hole provided for it was rendered more or less difficult by means of interposed wards, making it, to a degree at least, impossible to introduce the wrong key.

The warded type of lock was succeeded by the present day lever tumbler type, in which tumblers are interposed between the key and the bolt, making it necessary for the key to lift the different tumblers before the bolt can be withdrawn. This type of lock is considered secure in proportion to the number of tumblers used and the means provided for varying the relative amount of lift.

The bolt of this type of lock has fitted to it a member that passes into slots in the lever tumblers in the operation of its withdrawal, and the province of the key is to line up these slots in the lever tumblers so that they register with the fixed member on the bolt.

A later development of the tumbler type of lock is that known as the cylinder pin-tumbler lock. In this type of lock the obstruction consists of divided pins preventing the turning of the plug until these pins have been raised to a point where the division line between the different sets of pins coincides with the outer surface of the plug, and the inner surface of the cylinder, in which it rotates. When these points have been so lined up by the introduction of the proper key the cylinder may be rotated and the bolt withdrawn.

The inconvenience resulting from the use of the ordinary type of key lock, by reason of the fact that keys could be wrongfully duplicated, or they might in various ways come into the possession of persons not entitled to them, gave the necessary impetus to inventive genius, and the modern dial or combination lock was the result.

Coincident with the development of the dial lock is that of the changeable type of key lock, in which the arrangement of the tumblers or obstacles may be almost indefinitely varied. It practically, after being set up to a new key, becomes an entirely new lock and cannot be operated by any other key than that to which it is set up.

The development of the changeable-key type of lock is of great importance for the reason that a limited amount of security is frequently needed of a kind that cannot be afforded by the ordinary type of lock. This security is frequently furnished by combination or dial locks that are much more expensive.

The changeable key locks, until recently, have been of a design and construction that were very apt to get out of order and cause considerable inconvenience to the user.

Many efforts have been made to produce a simple lock of the changeable-key type, all of them depending upon the introduction of a double tumbler between the key and the bolt. The changeable-key lock that is being manufactured by the Herring-Hall-Marvin Safe Co. is the only one in which the obstacle that is interposed consists of a single member. The tumbler of this lock departs from the lever tumbler type previously employed in that it has no fixed pivot but can be properly called a balanced tumbler.

Its greatest merit is its simplicity and its substantial construction. In all other types of changeable-key locks the means provided for changing the combination are delicate, and in the ordinary operation of the lock the wear on these delicate parts is constant. In this lock the means provided for changing the combination are not in the least delicate, and the ordinary operation of the lock in opening and closing after it has been set up to a key causes absolutely no wear on the combination part of the tumbler, making the lock just as substantial, and as little liable to get out of order as the simple lever tumbler type of lock.

It is generally conceded by those who are interested in the manufacture and sale of locks that the changeable-key type of lock has been greatly limited in its use heretofore by reason of its delicacy, and its propensity for getting out of order.

As an evidence of the simplicity of the Herring-Hall-Marvin Safe Co. lock, it is necessary only to call attention to the fact that in this lock, which admits of over 59,000 different changes, there are but 14 parts, while in the highest type of changeable-key lock previously invented, which afforded but about 8,000 changes, there were over 40 parts.

Its application, while not exactly universal, is broad enough to enable it almost entirely to supplant the other types of key locks.

In the case of apartment houses, where tenants are constantly changing, the ordinary type of lock affords absolutely no security, for the reason that keys may be duplicated. With the changeable-key type of lock it requires but an instant of time to set up the lock to a new key and thereby render all previous keys inoperative.

The combination lock, as it is known to-day to distinguish it from the key lock, became a necessity when it had been demonstrated that practically all key locks could be picked. This fact was developed in the historic lock controversy of 1851, in England, when Mr. Hobbs succeeded in picking all of the best makes of locks.

A few years later in 1856, Mr. Linus Yale, Jr., succeeded in picking several of the Hobbs locks. It then became generally conceded that no difference what the obstacles were that were interposed between the key and the bolt, so long as an opening was left for the insertion of the key, this same opening provided means for the insertion of picks to raise the tumblers. Mr. Yale then turned his attention to the designing of a lock that could be operated in some manner other than by the insertion of a key, and the early type of combination lock was the result.

The combination lock, being in such general use today, needs no lengthy description. It consists of the tumblers, the bolt, a lever member interposed between the tumblers and the bolt, and a spindle or arbor, having on its inner end a driving tumbler and on its outer end a dial. The lever member, usually characterized as a fence, is, from the standpoint of security, a very important part of the combination lock.

The first locks were fitted with a gravity fence, and it was later found that the disk tumblers could be rotated so as to bring their notches in line with the fence even when the combination was unknown. The fence rested upon the periphery of the disks and could with patience and a delicate sense of touch, be felt into the notches one at a time until all of the disks were lined up, when the bolt could be retracted by simply turning the dial. This defect was a serious one. It was finally overcome by Mr. Emory Stockwell of the Yale Bank Lock Department, by the invention in 1884, of the balanced fence. This fence was so supported that it brought no weight to bear upon the periphery of the tumblers. It was fitted with a friction bearing and could be moved out of its neutral balanced position only when the tumblers or disks had all been lined up in registry with it.

This improvement rendered the combination lock absolutely unpickable. It, however, remained for the ingenuity of the burglar to devise ways and means for defeating even this supposedly perfect lock. It was evolved out of the fertile brain of some enemy to organized society, that a mental key always existed and could be secured by torture—the combination numbers were always known by some one. There began, in the year 1874, a series of bank robberies all over the United States, the most important of which were carried to a successful termination by reason of this one weakness of the combination lock.

It immediately became evident that a lock with absolutely no communication with the outside of the protected structure was necessary and essential to security, and the invention of the time lock followed. This was, and still is, to a large extent, used in connection with the combination lock. Its use prevents the operation of the combination lock until such time as the time lock has run down, and, by so doing, withdrawn its obstruction to the operation of the combination locks themselves, or the means provided for opening.

Meanwhile, in an entirely different field, inventive genius had been equally active by the invention of liquid high explosives, the fluidity of which could be increased by the addition of liquefied ether, so that it could be made to flow into the space surrounding the lock spindles or into the joint between the door and the frame. The burglar, without first securing any proprietary rights in the invention, adopted this method, and the battle of wits began over again, with the result that the lock makers finally evolved a motor device working in conjunction with a time lock, which made it unnecessary to connect the outside of the door with the inside by means of spindles. The motor after being set would throw the bolts, when the door was seated into the jambs, and would instantly retract them when tripped by the running down of the time lock.

The motor device has not been universally adopted for several reasons, mainly because spindles can be, and are, made so that they cannot be driven in or pulled out, and they can be, and are, made drill-proof They are ground into the doors so closely that no liquid can be forced around them.

In concluding that part of this paper which relates to locks, I desire to call attention to the fact that while practically all types of key locks can be picked, it does not follow that the key lock should be discarded, for the reason that the measure of security afforded by the lock need not be greater than that afforded by the protected structure itself. Manifestly a light wooden door affords very little security, yet millions of them are fitted with locks. Some with the common warded type, others with the lever and pin-tumbler types—all at least affording a measure of security equal to that of the protected structure itself.

That these locks can be picked is no argument against their use because entrance could be had in nearly all cases in an easier way. The inherent defect in all key locks, other than the changeable key type, lies in the facility with which keys may be wrongfully duplicated and used, rendering such locks of no security whatever.

(To be continued.)

* *Journal* of the Franklin Institute.

The Hoof of the Horse

THERE are toes on a horse's hoof just as there are on the foot of a human being or on the foot of any animal that resembles the human foot. Furthermore, a horse has "toe-nails." The horn of the hoof grows in pretty much the same way that a toe-nail does.

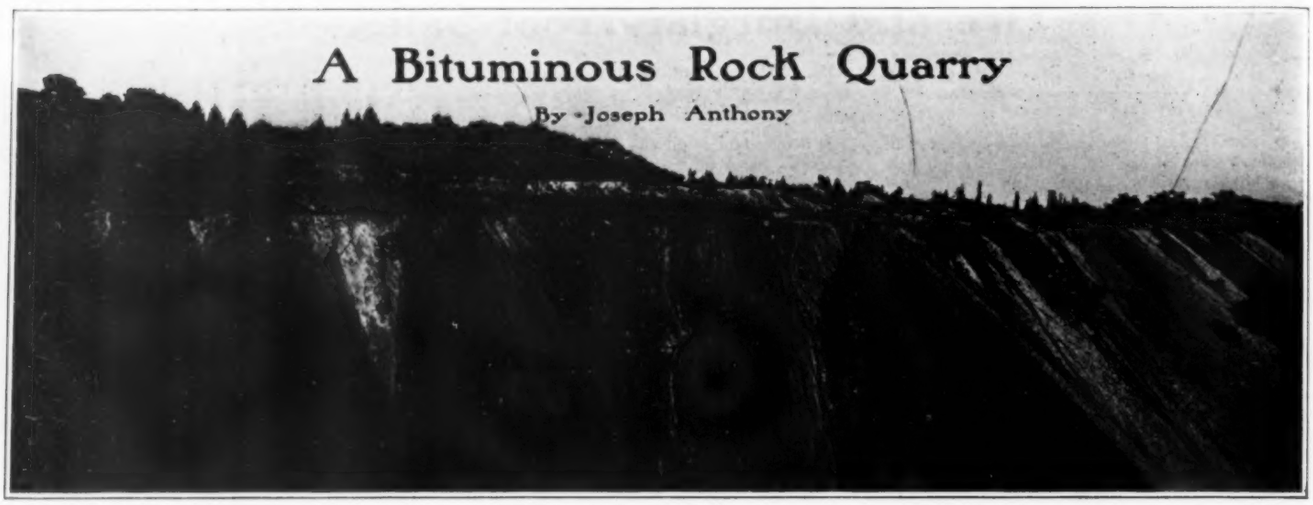
The growth of the hoof is more rapid in unshod horses than in the case of those wearing shoes. It grows still more rapidly in the case of horses that are well groomed and well fed. Generally speaking, however, the horn grows about one-third of an inch each month.

Hind hoofs grow faster than fore hoofs. The toe of the hoof being the longest part, it takes longer for the horn to grow there than at the heel. For example, the toe will grow entirely down in from eleven to thirteen months, while the heel will grow down in from three to five months.

As the new horn grows out, any cracks or defects in the old gradually work down to where they may be cut off, just as in the case of the growth of human nails one can watch the progress of a bruise from the root to the tip.

A Bituminous Rock Quarry

By Joseph Anthony



THE WASTE TAKEN OFF THE LEDGE, SHOWS THAT PART OF QUARRY IS ABOUT WORKED OUT

TEN miles northwest of Santa Cruz, California, there is an interesting deposit of bituminous rock. Here fifty-five men work the year round to get out 40,000 tons of the best road making material known. Of all the mines and quarries I have seen, this seems to be the most pleasant one in which to labor. High up on the side of a hill, three miles away and a thousand feet above the level of the sea, with a fine breeze most of the time, and where it is never too cold and with but a few days in summer when it is warm—is situated this clean, safe and profitable "mine."

After taking off 125 feet of waste shale there is exposed a 40-foot stratum of bituminous rock, except for a 10-foot layer of waste near the middle.

By running this rock through a steam cooker or heater, and without the addition of any binder, such as tar or asphaltum, it is spread upon the rock foundation and makes a clean and lasting surface for a street.

Asphaltum is the "binder" or mineral that makes this outcrop of sand valuable. It is found in many parts of the world, sometimes in a pure state, but more often mixed with fine sand, earthy matter or pebbles. It melts at about 212 deg. F., and in this form is known as bituminous rock. California is the only State in the Union in which it is worked commercially.

Macadam foundation covered with two inches of bituminous rock will cost about 23 cents per square foot; concrete foundation with two inches of bituminous rock will cost about 32 cents per square foot. Sidewalk will cost about 10 cents per square foot. In all this paving work, one of the most important things to do is to make a good foundation; without this, no matter how thorough the cooking and the laying of the cover may be, the work will go to pieces.

The fresh broken rock is very tough and waxy and in color it is not black, but a fine steel gray. Black powder is used to blow off a great mass before it is broken up into small pieces with giant powder, and with wedges, picks and bars. It weighs 80 pounds per cubic foot, and 10 tons make a load for a six-horse wagon to draw down to the railroad.

One of the stories told about this mine is that it was first worked in the '60's for the distillation of kerosene, and another is that later they tried to use it for paving material, but always got it too hard or too soft.

The man is still living near here to whom it was offered for little or nothing if he would take it off the owner's hands and make some use of it. He is poor and working for his living, while there is in sight 3,000,000 tons of rock worth $3 per ton, F. O. B.

Some fossils, and bones and teeth of animals are found in the 10-foot stratum near the middle of the outcrop.

This bituminous rock has probably been formed by a layer of sand becoming charged or saturated with crude oil, the lighter parts of which dry out or are vaporized, leaving the heavy asphaltum bare to bind the grains of sand together.

Charles Darwin—III*

By AUGUST WEISMANN

Concluded from SUPPLEMENT No. 1844, page 275.

THE principle of selection shows us how the thousands of adaptations in living beings which arouse our constant admiration may have arisen in a purely mechanical way. And they must necessarily have done so if the evolution of the living has resulted from the same forces and laws as the not living; in other words, if, in explaining natural phenomena, we can leave out of account altogether any forces outside of or beyond nature. The principle of selection enables us to do this, and therein lies its far-reaching significance. It is, I believe, the discovery of this principle that will make the name of Darwin immortal. Wallace, too, deserves a full share of the credit, although he did not base his theory on such a broad foundation of facts, and did not apply it in so many directions.

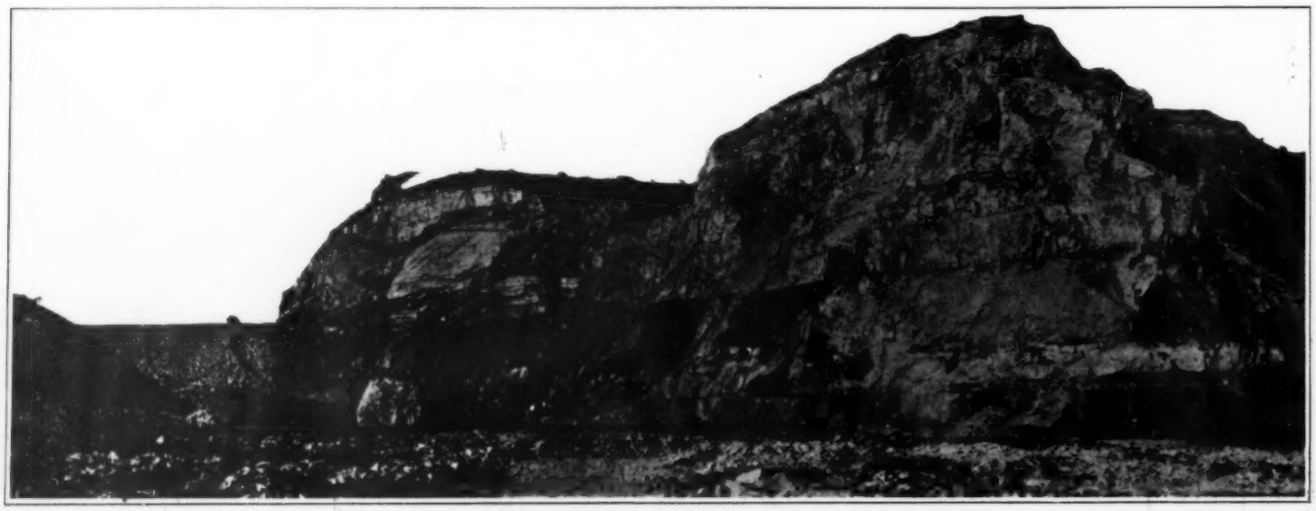
This principle is fully developed in "The Origin of Species by Means of Natural Selection," as, indeed, the title of the book shows. It might be thought that the publication of this book finished the labors of the hermit of Down, but this was not the case; it was followed by the richest creative period of his life. Between 1860 and his death in 1882 he issued a whole series of works, small and large, each of them based upon numerous observations and experiments, and most of them containing wholly fresh associations of ideas, usually connected directly or indirectly with the theory of evolution, and sometimes extending and corroborating it more fully. I must at least give a few indications as to the nature of these books.

In 1862 Darwin published his book, "The Various Contrivances by Which Orchids are Fertilized by Insects." Orchids often exhibit the most special and diverse adaptations to the visits of insects, and they help to make clear to us how flowers may have been developed in all their manifoldness in relation to the needs of their insect visitors.

In the same year and those following there appeared several treatises on "Dimorphism in the Flowers of Primula." Darwin had discovered minute differences in the length of the stamens in the same species, and he demonstrated that these differences are not mere chance variations, but are adaptations which secure the crossing of individuals and prevent self-fertilization. He obtained the proof of this through many careful experiments.

This was followed, in 1864, by a treatise on "The Movements and Habits of Climbing Plants," showing the different ways in which they climb—another study in plant adaptations. In 1868 appeared the great work begun in 1860, "The Variation of Plants and Animals under Domestication," and this book greatly extended and strengthened the basis of his theory of selection. The phenomena and laws of variation and heredity are discussed and illustrated by a wealth of examples, and the work concludes with a theory of heredity which he called "Pangenesis."

* An address delivered at the University of Freiburg on the occasion of the Centenary of Darwin. Reprinted from *The Contemporary Review*.



QUARRY SHOWING THE BARREN SHALE ABOVE THE 40-FOOT STRATUM OF BITUMINOUS ROCK

A BITUMINOUS ROCK QUARRY

"The Descent of Man" appeared in 1870. Up till that time Darwin had made no definite pronouncement upon this subject, though of course he must from the very first have deduced from the variability of species that man also was a product of evolution. He now discussed this view in detail in a two-volumed work, which also contained a fuller treatment of an aspect of the theory of selection only briefly sketched in "The Origin of Species." Here the phenomena of "sexual selection" are traced throughout all the animal groups in which preferential mating plays a part. The principle is illustrated by a positively overwhelming mass of detailed facts, and is shown to have been a factor even in the differentiation of the sexes in the human race.

Closely associated with this work is the one which followed it in 1872 on "The Expression of the Emotions in Man and in Animals." The birth of Darwin's first child in 1839 had induced him to record in a special note book all his observations on the gradual awakening of the sensations, and their expression on the features of the child, for he was convinced that even the most complex and delicate emotional expressions of man had their natural roots in animals, just in the same way as the part of the body and the mental faculties. For thirty-two years he followed out this idea, experimenting, observing, collecting facts, until finally he was able to write his remarkable and fascinating book, the first English edition of which consisted of 5,000 copies.

Darwin's next book appeared in 1875, and this also had been a long time in course of preparation. In ranging about the country during a summer holiday in 1860 he had noticed a dainty little plant, the "sundew" (*Drosera rotundifolia*), to the viscous leaves of which several small insects were usually found adhering. Many other collectors had noticed this, because of the difficulty of procuring a clean specimen for the herbarium. Darwin took a few of the plants home with him, and soon discovered that certain parts of the leaves exhibit movement as soon as small insects are brought into contact with them. This led him to the discovery of "Insectivorous Plants," and his book bearing that title was published fifteen years later.

In 1876 Darwin published a work on "Different Forms of Flowers on Plants of the Same Species," and in 1880, jointly with his son Francis, "The Movements of Plants." Finally, in 1881, the year before his death, there appeared "The Formation of Vegetable Mould through the Action of Worms." This last book, like some of the earlier short treatises, had no direct connection with the theory of evolution, but it illustrates in a very characteristic manner Darwin's eminently scientific mood, which led him to note everything that seemed unusual or interesting in the most ordinary things, and to follow it out till it led him on to new discoveries. How many hundreds of people, and even of naturalists, had seen the little earth-castings that cover the damper parts of our garden paths on summer mornings! These are due to earthworms, and are the remains of the decaying leaves on which they feed. The earthworms cover the whole land with fertile mold, and through their agency in the course of time the surface of the ground is raised, and bad soil is transformed into good.[1]

But no one had deemed the phenomenon worthy of attention. It is a case parallel with that of the sundew, which hundreds of botanists had passed by without ever suspecting that the adherence of the insects was more than a matter of chance.

The fruitful discovery of the "struggle for existence," too, was due to this vision of the true naturalist, who sees in what lies before him much that others pass by unheeding. It was certainly no chance that the "struggle for existence" first revealed itself to men who had spent the greater part of their lives in the open air; no chance that it was two travelers like Darwin and Wallace who first perceived the dependence of one species upon another and the competition between them.

From the little that I have been able to tell you of Darwin's life in Down you can gather what a rich, full life it was. You will now wish to hear something of the man himself and his character. Unfortunately I never saw him. An affection of the eyes which has troubled me for forty-five years, and has restricted my activities in many directions, prevented my traveling to England while Darwin still lived and was relatively vigorous. Therefore I can not sketch the impression made by his personality from experience. But we have a short autobiography which reveals his nature clearly, and in addition a most detailed and sympathetic picture of him by his son Francis.

MASS OF ROCK BLASTED OFF THE LEDGE AND BEING BROKEN UP

He was tall, nearly six feet in height, and his most striking features, the high forehead, the large prominent and bushy eyebrows, the blunt nose, and energetic mouth are well known. No one interested in Darwin's personality should fail to read both Francis Darwin's account of him[1] and his autobiography. Taken together they give a picture of the man which could not be more truthful and could hardly be more complete.

Add to this picture what we can gather from his scientific works, and especially from the accounts of his journey, and we find that he had a great and comprehensive mind, concerned in the main with general conceptions, yet possessing in a high degree the faculty of becoming sympathetically absorbed in detail. He took pleasure in small things as in large, and was able alike to study with the most painstaking minuteness the structural details of a flower or a crustacean, or to draw far-reaching conclusions from an enormous number of isolated facts. He possessed the fundamental qualities of a naturalist; great powers of observation and absolute accuracy; the most extreme caution in judgment is revealed in all his writings, and his presentment of his ideas is always simple and entirely free from arrogance or vanity, for a great natural modesty was one of the main features of his character. But his theories clearly show that he was not lacking in imagination, for they could never have been thought out without it. He was not a keen critic, grasping a thing quickly and illuminating it at once; he was, on the contrary, rather inclined to take too favorable a view of the work of others, and had a tendency, by no means very common, to acknowledge the achievements of strangers, and to take a positive delight in them. His mind was of the penetrating order which worked persistently at any problem until he began to see light on it.

He was not concerned with practical aims; he was an idealist who desired knowledge for its own sake, and not for any utilitarian end; a naturalist who worked for pleasure in the work itself, and rejoiced in the advancement of science his work brought about.

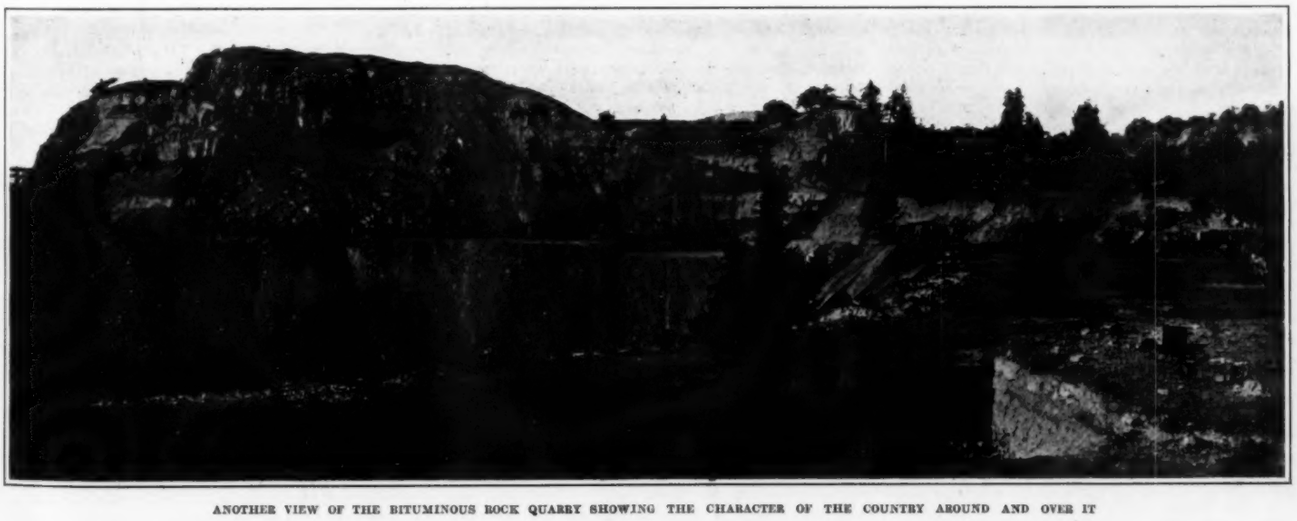
He was not lacking in ambition, but it was ambition on a large scale, not to gain fame and position, but to create works which should seem to him worthy. Fame came unsought, and, as he tells us, it was a satisfaction to him to feel that he was held in esteem by those whom he himself esteemed.

He has sometimes been called an amateur, and in a certain sense this is true, in as far as he worked in several different scientific provinces, each of which requires a man's whole strength. But he had full command over these different provinces, at least as far as was necessary for the end he had in view. He was certainly not a restricted specialist. The zoologists accepted him as a zoologist, the botanists as a botanist, perhaps also the geologists as a geologist. But he was not an expert in any, or rather, it would be more correct to say, he was so wherever he himself had done productive work. For he was essentially self-taught, and had passed through no normal school of zoology or botany, but with his great energy and unflagging industry he had acquired a profound knowledge from books and from personal intercourse with specialists, and every piece of work he did added to this store of knowledge. He was perhaps the last not merely to survey, but to do productive work in every domain of biological science. Yet I will not assert this, for we have all been convinced in recent times through the evolution theory that it is not enough to be at home in a single science; it is necessary also to have at least a general acquaintance with the essentials of allied branches.

Darwin has sometimes been accused of being one-sided, of caring for nothing but his science. But this was not the case; it is less true of him than of many specialists in natural science. He had a wide knowl-

[1] In regard to the earthworm, I must note that my countryman, Professor Hensen, the excellent zoologist of Kiel, displayed the same acuteness of observation and drew the same conclusions from the castings at the same time as Darwin did.

[1] "Life and Letters of Charles Darwin, including an Autobiographical Chapter." Edited by his son, Francis Darwin. London, 1887.



ANOTHER VIEW OF THE BITUMINOUS ROCK QUARRY SHOWING THE CHARACTER OF THE COUNTRY AROUND AND OVER IT

A BITUMINOUS ROCK QUARRY

edge of English literature, Milton and Shakespeare having been his favorite readings in his youth. In later life he had novels, historical works, and books of travel read aloud to him every day. He was fond of music, too, though, as we have said, he had no musical ear.

Darwin was a man not only of lofty, noble spirit, but of the tenderest feeling. Let anyone who doubts this read the touching pages in memory of his little daughter Annie, who died young; they form one of the most beautiful memorials ever dedicated by a father to his child. His son's picture of him, too, reveals the beautiful and intimate relations that prevailed between them, and the whole quiet and joyous life of the Darwin family testifies to the cheerful and affectionate disposition of its head.

It remains to estimate the influence of Darwin's theories on his time and on the future. But this is a task for which a whole book would not be too much, and a task, moreover, which could be better accomplished on the two hundredth than on the one hundredth anniversary of his birth.

We can at least say, however, that the influence was a great and many-sided one, and that it will endure throughout all time. All who know the position of science before 1859 will be ready to admit this; the younger generation have grown up so thoroughly under the influence of Darwin's ideas that it must be difficult for them to realize the state of matters before his day.

Let us speak of biology first. But was there a biology then? Strictly speaking, there was not; there was zoology, botany, and even anthropology. Each of these sciences consisted of a very large and well-arranged mass of facts, but with no intrinsic coherence among them. This was supplied by the theory of evolution. The different departments of science were not even then regarded as complete; it was well known that there were many gaps in our knowledge, but we were only seeking for missing details, whereas in reality it was the main thing that was lacking—the unifying idea which Goethe had sought for, and tried to supply in his theories of the plant prototype, and of the skull.

The science of embryology, or, as we now call it, ontogenesis, at that time consisted of a great number of observations, interesting enough, but without any recognized unity; it was not a harmonious structure, but a collection of finely-cut building stones. But what a change when the luminous idea of evolution was added! Life seemed to be infused into the stones, and almost spontaneously they formed a magic edifice. The ovum, now at last recognized as a cell, was seen to be a reminiscence of the descent of all higher animals from unicellular organisms; rudimentary organs, such as the rudimentary eyes of blind cave animals, were found to be sign posts indicating the racial history of these animals, and pointing back to their sight-endowed ancestors. This evolutionary view illuminated the whole science, and not embryology alone, but also "comparative anatomy," the understanding of the structure of animals. It became plain why the New Zealand kiwi should have little rudimentary wings under its skin, although it does not fly. It is not in order that it may conform to an ideal of a bird, as was previously thought, but because its ancestors had possessed wings which were used in flight.

Physiology also gained much, especially the theory of reproduction, of heredity, of organs, of the cell, and especially of the cell nucleus. I do not mean to say that all these were the direct result of the idea of evolution, but they have an indirect connection with it.

Anthropology gained quite a new interest after it was recognized that man, too, was a product of evolution. A vast number of problems presented themselves; it was necessary to investigate the gradual becoming not only of the body, but of the mind, the evolution of the Psyche and all that flows from it. Before that time there had been a history of language, of law, of religion, of art, and so on, but it now became necessary to carry these further back—beyond Adam and Eve to the animal ancestors. Undoubtedly a study of the phychology of animals is one of the essential tasks of the future! I can here only give a few hints without elaborating them, but I must emphasize the fact that the idea of evolution, in the form in which Darwin presented it to us, has given an impulse to new life and further development in every department of human knowledge and thought; everywhere it acts as the yeast in cider—it sets up fermentation. This has already borne rich fruit, and we may hope for much more in the future.

Our greatest gain from the theory of evolution has, however, been the evidence it affords of the unity of nature, the knowledge that the organic world must be referred back to the same great everlasting laws which govern the inorganic world and determine its course. Even if formal proof of this be still wanting, the probability is now so strong that we can no longer doubt it.

It is not only the theory of evolution as a whole, but the active principle in it, the principle of selection, that is transforming and illuminating all our old conceptions. It is teaching us to understand the struggle, silent or clamant, among human races, their rivalry for the possession of the earth, and to understand, too, the composition of human society, the unconscious division of labor among the members, and the formation of associations. The development of "classes" and their union in a State appears in a new light when looked at from this point of view. In this department a good deal has been already accomplished.

The study of human health must be particularly influenced by the theory of evolution, and a beginning has already been made in this department also.

But there is another and very important point in regard to which the theory of selection must be our guide. If we take a survey of the evolution of the world of life as we know it, we see that, on the whole, it has been an ascending evolution, beginning with the lowest organisms and advancing through higher and higher to the highest of all, man himself. It must be admitted that at certain stages in this evolutionary series we find retrograde steps (as, for instance, parasites and sedentary animals), but on the whole the direction of evolution has been an ascending one.

I see no ground for assuming that this will be otherwise in the future. According to the principle of selection the best will survive in the future as in the past, and mankind will ascend. I do not believe we are likely to undergo any essential changes in a crude physical sense; we are not likely to grow wings, and even our mental powers may not be capable of much further improvement, but ethical improvement seems to me not only possible, but probable, on the principle of selection. Mankind will never consist of wholly selfless saints, but the number of those who act in accordance with the ideals of a purer, higher humanity, in whom the care for others and for the whole will limit care for self, will, it is my belief, increase with time, and lead to higher religions, higher ethical conceptions, as it has already done within the period of human existence known to us. But here again I can only indicate without following out my ideas. I wished to express them, because the principle of selection has so often been applied in an inverted sense, as if the brutal and animal must ultimately gain the ascendency in man. The contrary seems to me to be true, for it is the mind, not the body, that is decisive in the selection of the human race.

Thus we see the principle of evolution intervening, transforming, re-creating in every department of human life, and thought, and endeavor. We owe this principle, which has been so fruitful in results, mainly to Charles Darwin, though he was not the only one nor the first to think it out. But it was he, with Wallace, who secured it its place in science and made it a common possession of mankind by working it out in all directions, and supporting it with another principle, that of selection, which explains the riddle of the automatic origin of what is suited to its purpose in nature. Thus he cleared away the obstacle which would otherwise have stood in the way of the acceptance of the theory of evolution.

By all this he has earned enduring fame in the annals of science. His own country has not been ungrateful to him. A colossal statue of him in marble decorates the British Museum; from the background of the entrance hall he looks down on the passers-by with the calmness of the sage. His mortal remains lie in Westminster Abbey beside those of Newton.

Fate, too, was kind to him. He could truly say that his life was a happy one, for it was filled with a great idea, and he was supported by the consciousness that Goethe expresses through his Faust: "Es kann die Spur von meinen Erdentagen nicht in Aeonen untergehen." This is true of Darwin, and we may think of him as one of the great immortals among men.

The Modern Motor Car*

Ten Years' Progress

By W. W. Beaumont

Motor vehicle engineering, as generally understood, may be said to be all modern, although in fact it was born in England about 85 years ago. Taking, however, only the ten years of the present century, a survey of the advances which have been made will show that as a branch of engineering its progress has been unprecedented, that the industry it has established has reached the incredible, and that the new knowledge it has acquired to the advantage of metallurgy and other arts and manufactures has placed it in the front rank as a philanthropist to science.

Early in 1900, the inventions and patient investigations of Daimler, Butler, Maybach, Benz, and a few original contributors in a less degree, fostered by the mechanical skill of Levassor, Peugeot, Mors, Renault, and others, had proved so full of practical and commercial value that a large number of motor vehicle manufacturers had become established in Germany and France, together with a few in England, including the Daimler Company, the Lanchester, the Wolseley, the New Orleans, Star, and Napier. Vehicles from all these makers and more were among the 65 which started from Hyde Park Corner in April, 1900, on the 1,000-mile endurance and hill-climbing trial of the Automobile Club, and of them 49 with more or less complete records entered the Crystal Palace and were exhibited there in the following month. With two exceptions the whole of the vehicles exhibited were fitted with engines of the types originated by the first-named inventors and makers, the exceptions being small steam cars, one of a type now not seen in this country. Most of those which had not the type of gear transmission of the Daimler-Levassor origin, and Daimler, Panhard, Levassor, and Mors construction, were of the very small powers now out of date.

* Engineering Supplement of the *London Times*.

THE ENGINE.

To start from this preliminary as to what the courts call the "state of the art" of ten years ago, a few comparisons may be made with present conditions. In the first place, the power of the internal combustion engines used to-day is on an average at least three times that of 1900. In that year the 12-horse-power Panhard engine represented the most advanced form of construction. A Mercedes (Cannstatt Daimler) car of nominally 24 horse-power ran in the Nice-Marseilles race of March that year, but its average speed was from five to ten miles less than that of five Panhard cars in the same race. All these engines had hit-and-miss governing and valve-operating gear with exposed cam shaft gearing, but they for the first time used the magneto-ignition apparatus which had been for years used by the French gas engine makers. Up to that time the engines of this type had been fitted with the flame-heated ignition tubes, with consequent inferiority as to period of ignition and pressure effects. Mors had, however, used one complicated type of electrical ignition, and Benz had always used another and simpler form, but confidence in electric ignition was not established until after the Bosch magneto had been in use some time. To-day electric ignition is universally fitted, and the cars run many thousands of miles with it without any uncertainty, engines of the same diameter of cylinders giving very much higher actual power than they did formerly. At noise trials in 1900 it was a question of which engine made least noise; now it is more nearly a question of which engine makes any, even though quadruple the power is developed.

These advances have been obtained by the employment of valves of dimensions, forms, seating, and ports of now known proper forms, together with inclosed valve-operating gear beautifully made; by precise construction of valve-operating mechanism and cam forms; by the use of modern tools and methods which insure accuracy equal or superior to standard gages of a generation ago; and by the utilization of high-property metals which permit a lightness in the construction of parts not dreamed of but a few years ago. Steels of from 40 to 100 tons tensile strength and considerable toughness have been made at the suggestion of the automobile builder and largely as a result of the strenuous competition for pre-eminence in the race and other trials organized by the French and by the Royal Automobile Club.

Things and materials which were the best possible in 1900 might to-day be looked upon as makeshifts,

and very possibly the same remark will be true in 1920; but it is safe to say that there is no more perfect piece of machinery in the world to-day than the engine and other mechanism of the well-made motor vehicle, and there never has been such perfection in the material, workmanship, and performance of the finished thing.

TRANSMISSION AND GEARS.

In 1900 the transmission mechanism was only beginning to be so completely inclosed as to run immersed in the most suitable lubricant, and the transmission was in nearly all cases by chains exposed to every cause of wear. To-day by the use of the excellent steels that have been brought into existence for the purpose the gear wheels are of half, or less, the weight possible in 1900; and they run in oil-tight gear boxes so that the teeth have hardly time to squeeze the oil from between their contact surfaces before they have passed each other, with the result that their wear is almost insensible after propelling a car thousands of miles at average speeds which in 1900 were racing speeds.

The change speed gear of nearly all the cars of to-day, including the best, is of the longitudinally sliding type, as it was in Levassor's cars of 1895. This was then to the mechanical engineer a makeshift, but he had not then made the experiments he has since made with every other type of gear he has been able to devise. He therefore did not know that ten years would only show him that what he thought a makeshift was a good devise, because by careful attention to the relations between the different speeds of the gear, by study of the number, pitch, and form of the teeth, by the removal of unnecessary inertia stresses by lightening parts the acceleration of which had to be suddenly varied, and by the improvement of the transmission to the gear, this type of gear change could be made the best possible when all practical requirements are considered with reference to both the hypothetically and the expediently best.

Transmission to the driving axle by exposed chain is now but little used, and direct driving by either worm and wheel, as first used in motor cars by Lanchester, or by bevel pinion and wheel, all parts being inclosed, is to-day most in use. The whole of the parts are made of very high grade materials, and, in good cars, are fitted with a precision impossible in earlier years. The improvements in the change speed gear and final transmission gear make it possible, in cars having the now usual "flexible" engine and good clutch, to change from one speed ratio to another in such a way that there is neither jerk nor noise, and the passenger in a car does not know a change has been made. Improvement in this respect, however, is much wanted in motor omnibuses, though with the changes that are being made and are yet to be made it will be forthcoming.

In 1900 speeds were much lower than are common to-day, and comparison of the gasoline consumption then and now is not likely to be very trustworthy, because it is difficult to allow for road and air resistance at the speeds at which consumption trials were made in 1910. Without such allowances the comparison is in favor of the best 1900 car—which is obviously wrong, especially when the smaller weight of car per horse-power to-day is taken into account. It is not, however, at all certain that the carbureter of to-day is better suited to the average engine of to-day than was the simple Maybach carbureter to its engine of 1900, and there is no reason why it should be. Misconception prevails even yet as to carbureters, as is shown by the fact that the best surface evaporator carbureter even now does not give the engine a carbureted air by which it can use gasoline more economically than with the ordinarily good jet or multiple-jet carbureter. The makers of motor vehicles on a large scale have devoted the most painstaking and unrestricted experimental attention to this detail of the motor car, well knowing the differences between the thing that will perform best under the varying conditions and circumstances of a carbureter on a car and the perfect carbureter in a laboratory.

BODYWORK.

The car of 1900 had driving wheels larger—and sometimes much larger—than the front wheels, and the general dimensions were influenced by those of ordinary vehicles. Conflicting requirements thus made the motor carriage body uncomfortable as a consequence of height of floor and deficiency of leg room. Much was said about inartistic design of bodies—but no artist offered any solution, complain as much as he would of what was made. Ultimately the motor vehicle has become the most comfortable and luxurious of all known vehicles at the same speed on the same road, as a result of the efforts of the motor car builder. He has had to produce bodies which are not only accepted as having every evidence of fitness, but which will also withstand the shocks, strains, and vibrations of high speed over bad roads, and show less of depreciation than would any other body work with a tenth of the mileage and one-third of the average speed. It is known that when cab and hansom owners had to adopt rubber tires they saved a large part of the whole cost by the difference between the cost of the body upkeep with and without such tires. What the cost of the old cab and hansom upkeep would have been at an average speed of say 25 miles an hour, with a travel of 400 miles a week, can be estimated by those who are informed on these matters, and they will be able to affirm that the improvement during the last ten years in body building and finish, as applied to motor vehicles, is the difference between an admittedly temporary makeshift and a satisfactory stage toward perfection.

A very great part of the whole of the depreciation of a motor vehicle is caused by the severity of the jolting, twisting, and vibration resulting from modern speed on roads most of which are not modern. Much may be done by elaborate springing, by shock absorbers, which refer the shock to the wheels and axle, and by other means, but ingenuity of this kind is expended in fighting what must be hoped to be a declining enemy. It is not a sensible proceeding that insists on multifarious appliances which may enable a car to run at high speeds on badly-paved roads when it is known that generally the car will in fact run on much better roads and that a slow speed on the bad ones will avoid most of the trouble and discomfort and thus make these appliances unnecessary. To a very great extent the motor problem is a road problem, and although all horse-pulled vehicle owners have always taken bad roads as they do thunderstorms, there is no reason why engineers and motor car owners should do so, especially as good roads, well and continuously maintained, are in the end cheap.

DURABILITY.

The comfort of motor vehicle travel has increased in the last ten years to an extent that can only be known by those who traveled much by car in all seasons in 1900. Involuntary stoppages on the road, except for tire punctures or the like, are many hundreds of miles apart, and stoppages owing to mechanical defect in a good and well-kept car are now causes of surprise. The 15,000-mile trial of the Rolls-Royce car by the Royal Automobile Club shows what is possible in this respect, the wear at the end of that distance not being measurable in any but an unimportant detail, and the whole cost of repair only a few shillings. On other cars the writer has run 7,000 miles without a single mechanical stop, and over 4,000 miles without a single tire stop of any kind. This is mentioned because it has been suggested that things "are not what they seem" in motor vehicles, and because it is said that durability and other trials are wanted. But durability trials are being carried on now by about 6,000 cabs and about 1,000 motor omnibuses in London alone, and by many thousands of owners of other vehicles of various kinds. A great deal of this practical trial running may be said to be, through the owners, within the cognizance of the makers of the vehicles; they and the omnibus and cab companies and their engineers are getting the experience, the real knowledge of the weaknesses, the defects, and the good qualities and points. A motor omnibus runs from 25,000 to 30,000 miles a year, and during that time its engine and gear will make many millions of revolutions, and have to be equal to the arduous work of starting, hauling, and stopping a vehicle and load of over six tons every few minutes.

SIDE SLIP AND BRAKES.

During the ten years many devices for preventing side slipping have been invented, but they have not been free from the defects that (1) they involve inconvenient additions of appliances; (2) they need prevision on the part of the driver, alertness not being sufficient; (3) they destroy the road surface; or (4) they are ineffective. Good driving and cleanly roads are the true side slip preventers.

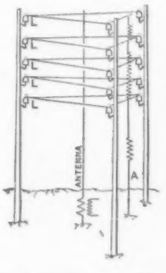
Brakes are now so generally well designed and well made that on the good cars of to-day, if kept in adjustment, they are quite trustworthy. A brake which is more than sufficient to skid the wheels is easily obtained, but it is not a very desirable thing to put into the hands of most drivers, and additional stopping appliances would probably be more expensive or troublesome than the wear of tires so long as tires are not skidded. A perfect brake such as an electromagnetic brake, without surface contact, but depending only on cutting lines of force, is hypothetically pretty, but the ordinary brake which wears and causes some wear of the tires is in practice a better expedient—just as a leather boot sole which wears out is better than a copper sole which would last a lifetime. In conclusion, then, it may be said that the improvements made in the motor car during these ten years have been such as to earn universal appreciation, even if not to remove all opportunity for the adverse and non-constructive critic.

Poisoning by Gas from Heaters

A FACT which has a great practical bearing was brought out not long since by two French scientists, relating to the slow poisoning of the system by gases given off from certain kinds of heaters used in private houses or hotels. Heating by hot air is not free from danger, according to their information, and it appears that thirty-five persons who lived in a large hotel where hot air heating was used, were subjected to a slow poisoning by gases and this gave some bad effects. It is carbon monoxide gas which causes the poisoning in this case, and only a small quantity is needed, such as 1 in 1,000 or in 10,000. In the present case some of the persons who lived in rooms which were free from this gas, did not show any bad symptoms. As to the others, they showed troubles of different kinds, nervous, digestive or general. Among the nervous troubles were noticed vertigo, fatigue, insomnia or neuralgia. As to general symptoms, we note that the persons lost flesh and became pale. These effects come from living for some time in the contaminated air, but when the persons went to another place the symtoms disappeared or at least were lessened. Examination of the furnaces showed that they were very defective in their construction. It appears that some cities have the habit of mixing water gas with city gas, and for heating purposes this is a positive source of danger, and mortality from such causes is increased. We should remember that bad effects from the presence of gases are not easily detected at once, as the action is very slow, and thus the system may in time be very much affected when it is too late to take the needed precautions. Drs. Courmont and Mouriquand brought out these facts before the Paris Academy of Medicine.

Wireless Receiver Trouble

THE receiving apparatus of a wireless station is sometimes affected when no aerial waves are coming to the antenna from another station. This phenomenon is known as receiver trouble. It sometimes becomes very annoying, and in the tropics often makes regular communication impossible during a period of twenty-four hours. Investigations made at the Graefelfing station indicate that the trouble is due to atmospheric electrical disturbances caused by radioactivity.



ANTENNA SURROUNDED BY FARADAY'S CAGE

The earth is usually negative with respect to the air, and the negative charge of the antenna favors the accumulation of radioactive deposits, which strongly ionize the air in the vicinity. Hence each wire of the antenna is surrounded by a cylinder of air of abnormally high conductivity. The protrusion of the earth-connected antenna into the atmosphere also distorts the equipotential surfaces and produces an abnormally high potential gradient over the antenna. The combination of high potential gradient and high atmospheric conductivity produces an abnormally great flow of electricity from the air to the earth, through the antenna, and the variations of this flow set up electrical oscillations which affect the receiving apparatus.

These disturbances can be prevented by inclosing the antenna in a Faraday's cage, with all of its wires placed horizontally, so that they have no component in the direction of the electrical vector of the waves coming from other stations and, consequently, do not interfere with the reception of messages. These horizontal wires, denoted by *LL* in the diagram, are provided with an aperiodic or non-oscillatory earth-connection *A*.

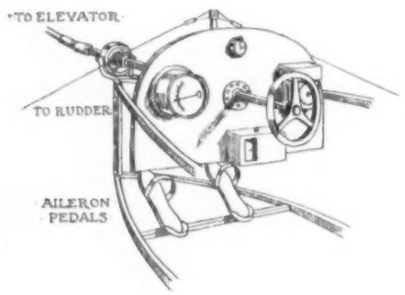
BEFORE a French scientific society M. Jouve has described the remarkable resistive property of ferro-silicon, and other alloys of silicon. Nitric acid, even as a vapor, does not affect these alloys at all. Sulphuric and hydrochloric acid also have no effect. The same is true of acetic acid. The high price of platinum gives importance to ferro-silicon as a substitute to be used in the manufacture of acid-resisting vessels, but the alloy possesses a disadvantage in its brittleness, and the thickness and weight of the vessels made of it.

The Maurice Farman Biplane

Scale Drawings of the Machine that Flew from Paris to the Puy de Dome

THE Maurice Farman machine, as first built, toward the end of 1909, was distinguished by the fact that it had vertical panels at the rounded extremities of the main planes and ailerons on the lower plane only. The chassis was composed of skids and castor wheels. Two smaller wheels supported the tail. In 1910, after an alliance had been made between Henry and Maurice Farman, the side panels were discarded and four ailerons were used. The two small wheels supporting the tail were replaced by a skid. From this period also dates the adoption of a rear elevator acting in conjunction with the front elevator. Later, in the military model, the upper plane was extended. In the Puy de Dôme model the castor wheels have been exchanged for those of the Henry Farman type, and the leading edge of the main planes is now in line with the front uprights instead of being a foot in advance of them.

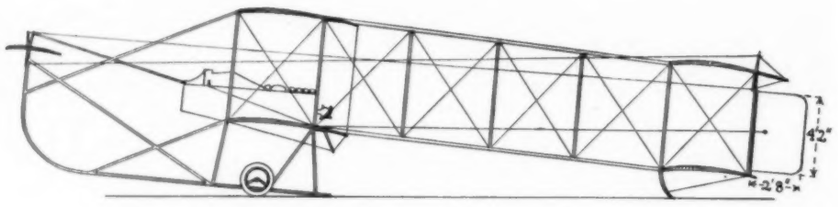
The surface of the main planes, which are covered with Continental fabric, is 635 square feet, and the aspect ratio is 8 to 1. The weight of the machine is about 1,210 pounds, and the speed 48 miles per hour. A 60 horse-power Renault air-cooled, 8-cylinder, V-type motor has always been employed. The Chauvière propeller is driven off the half-time cam-shaft



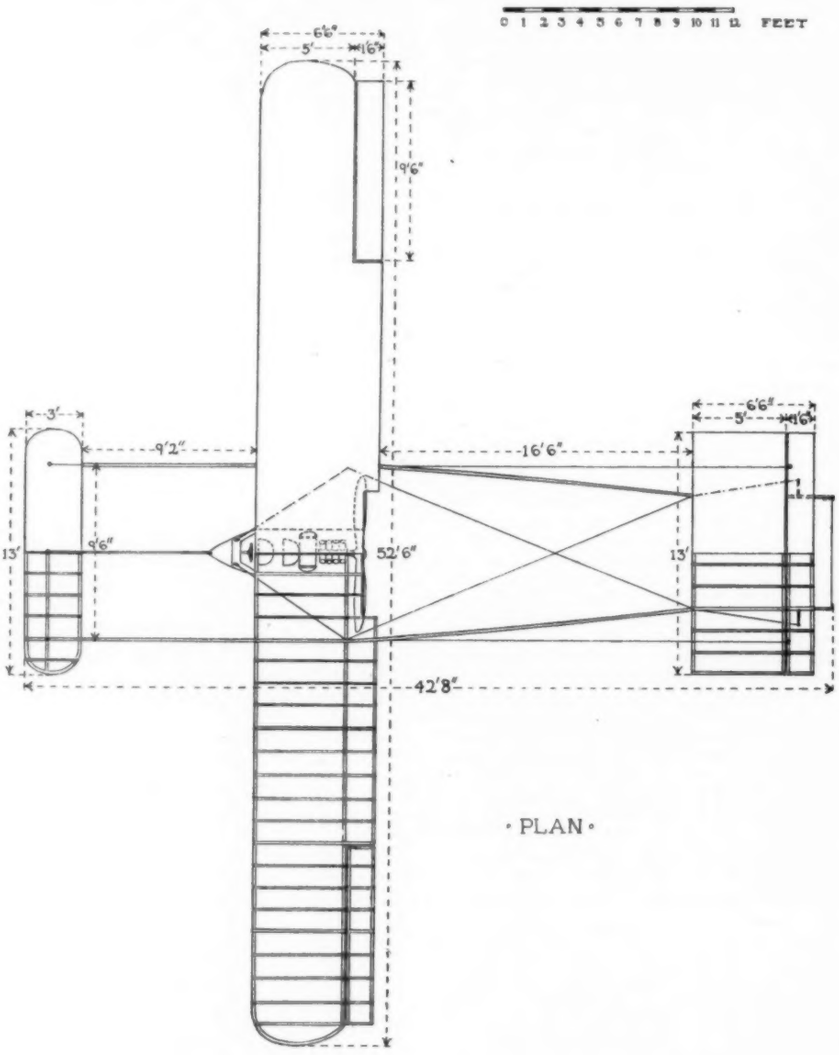
so that at a normal engine speed of 1,800 revolutions per minute the propeller makes 900.

Maurice Farman was the first to use a covered body inclosing the seats and engine. Some such construction is now recognized as essential for the comfort of the pilot and passenger. In the accompanying sketch of the control the fabric inclosing the body is not shown, for the sake of clearness. On the dashboard are placed a gradient indicator, a timepiece, an aneroid barometer, and a recording barograph. The handwheel is mounted on a square shaft which slides on rollers at the forward end. Forward and backward motion of the shaft alters the angle of the elevator, and rotation of the handwheel controls the rudders. The pedals work the ailerons.

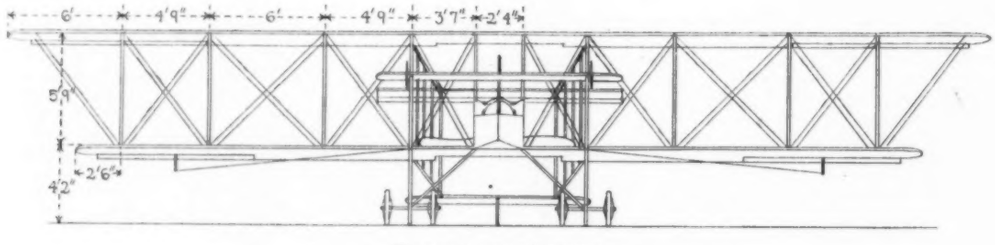
On October 28th, 1910, Maurice Tabuteau, on a Maurice Farman machine, broke the world's record (244 miles in 5 hours, 3 minutes, 5 seconds) by a flight of 290 miles in 6 hours, 1 minute, 35 seconds. Later Henry Farman captured the duration record (making it 8 hours, 12 minutes), and Legagneaux the distance record. Tabuteau recaptured the distance record on December 30th by a magnificent flight at Buc of 365 miles in 7 hours, 48 minutes, 31 seconds,



• SIDE ELEVATION •



• PLAN •



• FRONT ELEVATION •

thereby winning the Michelin cup for the longest flight of the year.

The greatest triumph of the Maurice Farman machine is the winning of the prize of 100,000 francs offered exactly three years before by the Michelin brothers. On the morning of the 7th of March Renaux and Senouque left Paris for the summit of the Puy de Dôme mountain, 235 miles distant. They reached their destination in 5 hours, 10 minutes, 46 seconds, including a stop of 14 minutes at Nevers. This achievement marks an epoch in the history of aviation, as it is the first successful long cross-country flight with a passenger made in less than six hours. It demonstrated the possibilities of the aeroplane for the rapid transportation of passengers from point to point, and without doubt before the summer is over we shall see aeroplanes regularly used for this purpose.

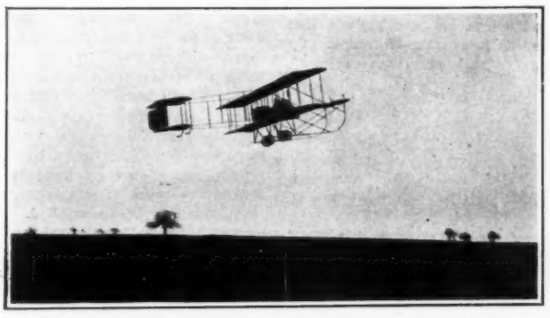
ON the need of the aviation world of a grand prize for a stupendous feat, the Michelin brothers—France's great tire manufacturers—based their $20,000 prize three years ago. The great flight they proposed was one of 222 miles from Paris to the Puy de Dôme mountain, a 4,813-foot peak located near their works at Clermont-Ferrand. The aviator must carry a passenger and make the flight within the elapsed time of six hours, circling the Arc de Triomphe at Paris at the

start and turning about the steeples of the cathedral at Clermont-Ferrand before the finish. As the summit of the mountain afforded a very constricted landing place, it was generally supposed that an aviator attempting to land upon it would demolish his machine and perhaps be killed or seriously injured; and consequently, a month or two ago, the Michelins attempted to modify the rules to read that a safe landing must be made without breakage of the machine. This modification was not allowed, but Renaux fulfilled it nevertheless.

At the time the Michelin prize was offered, the best records abroad were for height, 12 meters (39.4 feet), made by Blériot in August, 1907, and for distance and duration 2,004 meters (6,575 feet) and 3 minutes and 39 seconds respectively (made on March 21st, 1908—two weeks after the trophy was offered—by Henry Farman). As for carrying a passenger, this had never been done, even by the Wrights in America. So improbable did it seem to the donors that the feat their prize called for could be accomplished, that they allowed a period of ten years in which it could be won.

The marked advance in aviation in 1909 and the far greater and more rapid progress made last year caused two attempts to be made last summer. One of these—that of the Morane brothers in their Blériot monoplane—resulted in an accident soon after the start owing to a reserve can of gasoline breaking loose and interfering seriously with the steering gear. The monoplane plunged to the ground and the two brothers were both badly injured. The other attempt by Weyman, a young Haitian, in his Henry Farman biplane, was much more successful, Weyman getting within fifteen or twenty miles of his destination but being compelled to descend on account of night setting in after he had lost his way and made several descents *en route* in the fog.

The first of last month Weyman, with his Henry Farman biplane, and Renaux, with a similar Maurice Farman machine, began practising making long glides from heights of 1,000 feet or so, and alighting upon a small marked-off spot. Next they perfected themselves in alighting upon such a spot with a passenger.



MM. RENAUX AND SENOUQUE STARTING ON THEIR 235-MILE FLIGHT FROM PARIS TO THE PUY DE DOME

On Monday, March 6th, Renaux was ready to attempt the great flight, but weather conditions at the Puy de Dôme were not favorable. The next morning, however, word was received that the air was clear, with no wind. As there was only a light and favorable northeast breeze blowing at the aerodrome at Buc, Renaux got out his machine, and climbed aboard with his passenger, M. Senouque. He left the ground after a short run at 8:50 A. M., and flew to the Aero Club park at St. Cloud, where he crossed the starting line at 9:12:34 2/5. Heading straight southward, he flew above the aerodrome of Juvisy at 9:28. Fifty minutes later he passed over the railway station at Montargis, and flew down the line at an elevation of 1,000 feet, overtaking and beating an express train. In another hour he crossed Cosne at high speed, and at 11:30 La Charitié at a height of 600 feet. A quarter of an hour later the machine was sighted by the great crowd that awaited it at Nevers, where Renaux had planned to alight and take on fuel. After circling gracefully about the cathedral of St. Cyr, the aviator alighted upon the aerodrome of the "Lone Poplar" at 11:53:30. His time for this first stage of the journey (141.5 miles) was 2 hours, 40 minutes, 55 3/5 seconds, and his average speed about 52¾ miles an hour. He reported heavy wind gusts near Briare, but the favorable wind had enabled him to maintain a high speed.

After a stop of about a quarter of an hour for luncheon, Renaux re-started at 12:07:37 P. M. In an hour and a quarter he reached Moulins. An immense crowd awaited him in the country thereabout. He flew over the city at a height of 1,200 feet and M. Senouque waved to the people that all was well. Following the valley of the Allier he soon reached Gannat (1:37 P. M.), and at 1:55 the biplane was above Riom and almost at its destination.

At Clermont-Ferrand, when the town clock struck 2, the great crowd assembled about the cathedral and up in its spires gave a cheer as those at points of vantage were able to discern a gray speck on the horizon. Plainer and more distinct it grew, and larger and larger as it approached at a height of 1,500 feet or more. Fourteen minutes later the biplane passed over the cathedral spires amid tumultuous applause, and, turning sharply, headed for the Puy de Dôme, which was dimmed by a light fog. In 13 minutes more it ascended some 3,500 feet, circled about, and descended easily upon the spot prepared for it, which was only a few square yards in size and was marked by wide red bands on the rocky ground. After a magnificent *vol plané*, the biplane alighted easily and Renaux, stiff with the cold, was helped from his seat.

In describing his trip M. Renaux said that soon after the start from Paris he suffered with cold and with cramps in his stomach. So hard did he have to work at his controls to maintain equilibrium, and so badly did he feel, that when he reached Montargis he almost made up his mind to descend. Luckily, however, the fog dissipated and the weather improved, giving him new courage and causing him to keep on his way. His companion, who was busily engaged studying the map, encouraged him by nods of his head. Near Cosne they came upon the river Loire, and for the rest of the journey they followed this and the Allier, and had no difficulty in finding their way. Nevers was reached and the stop made for replenishment of fuel and for luncheon, as told above. Once more on his way Renaux had some doubts of his accomplishing the journey in 5¼ hours' time, as he had bet his friends he would do if he had good luck and good weather. He wondered if the Puy de Dôme would ever show itself on the horizon. He was looking anxiously for the mountain and finally, at Gannat—28 miles away—he discovered it. He then began to climb from 2,300 to 5,900 feet, estimating that this height would be necessary in order to descend upon the summit of the mountain. At Riom he saw loom up in the distance the spires of the cathedral which were his last turning point. In less than ten minutes the machine was above Clermont, and he was within ten minutes of his goal. He wondered if, like the unfortunate Chavez, he would pay with his life for the gigantic victory he had all but accomplished. He had been climbing continuously and now found himself at too high an elevation. At this moment he was at Braque, at the fork of the roads which lead to Moreno and to Ceyssat. He descended again, little by little, as he approached the summit. Finally, at just the right distance, he cut off the spark and glided magnificently to the summit of the famous Puy de Dôme.

THE BIPLANE APPROACHING THE PUY DE DOME

The observatory can be plainly seen on top of this 4,813-foot mountain.

The distance covered in the first stage of this flight, that is, from St. Cloud to Nevers, was about 141½ miles, while the balance of the journey to Clermont-Ferrand and the Puy de Dôme was 93½ miles. The first half of the journey was covered at a higher speed on account of the wind, which was favorable. The last half was covered at an average speed of 41 1/3 miles an hour, the time in flight being 2¼ hours. The total elapsed time was 5 hours, 10 minutes, 45¾ seconds. Deducting the stop at Nevers, the total time in flight was 4 hours, 56 minutes, 38 3/5 seconds, which corresponds to an average speed of 49¾ miles an hour—a remarkably high average considering the amount of "climbing" that was done during the trip. It will thus be seen that the journey was accomplished with 50 minutes to spare, as the time allowed for the flight was 6 hours.

THE BIPLANE GLIDING TO THE SUMMIT OF THE MOUNTAIN

The Chemistry of Inks in Handwriting*

Things the Expert Must Know

By C. Ainsworth Mitchell, B.A. (Oxon), F.I.C.

BEFORE giving an account of some applications of chemistry in the direction of the general principles underlying the chemical methods of distinguishing between different kinds of ink in handwriting, I may, perhaps, be allowed briefly to recapitulate the main outlines of the theory, and to add some details by way of illustration.

Ordinary writing ink is essentially a mixture of a decoction of galls with a solution of copperas (ferrous sulphate), which slowly interact to form an iron tannate that gradually becomes oxidized by exposure to the air, and gives the black pigment of handwriting.

Characters written with a pure iron gall ink are nearly colorless when first put upon paper, and a considerable time is needed for the insoluble black tannate to be formed within the fibers.

Prior to about the end of the eighteenth century, inks were exposed to the air or boiled, so that a partial oxidation might take place within the fluid, and thus give some depth of tint to the product before it was used for writing. The chief objections to such partial oxidation are that deposits are formed in the bottle, and prevent the ink flowing smoothly from the pen, and that the fluid has not the penetrating power of an unoxidized ink. Such inks, however, are still on the market, under the name of "Japan inks," but they are but little used, their place having been taken by unoxidized inks, in which the black pigment is, as it were, in a latent condition, and a second pigment, such as indigo, logwood, or an aniline dye-stuff, is added to give a color to the writing pending the formation of the iron tannate.

The dye-stuffs employed in the commercial inks of to-day vary in color from pale greenish-blue to indigo and deep violet, and no two give identical reactions—at all events when mixed with iron tannate to form the pigment in writing. It is mainly owing to the differences in these provisional coloring matters that it is possible to distinguish between handwriting written with different kinds of ink.

In the old type of iron gall ink, in which no such second pigment was used, it would only have been possible to distinguish between different makes of ink in handwriting in exceptional cases, such as when a large excess or a great deficiency of iron had been used. Such irregularities in composition might readily occur, however, for in the days before the ink manufacturer could have made a living, writing was a polite accomplishment restricted to those who could afford the time, and the ink was made at home. Each housewife had her recipe for making a good ink, and its preparation was as much within her province as the making of cordials or the baking of bread.

A particularly interesting example of a domestic recipe, which was handed down as an heirloom, is shown in the accompanying figure, which Mr. G. Weddell has kindly allowed to be reproduced.

This was taken from a manuscript collection of old family recipes dating back into the sixteenth century, which Mr. Weddell has published in *facsimile* (*Arcana Fairfaxiana Manuscripta*, 1890). Directions are given for making everything needed for household use, from apple pasties to cures for the king's evil, and among its odd assortment of items are included several recipes for making ink, of which the example (Fig. 1), which was probably writen toward the close of the sixteenth century, is typical.

The directions here given are to soak five ounces of galls in one quart of rain water (or claret or red vinegar) and to boil the decoction, after five days' standing, with four ounces of copperas and three ounces of gum.

Ink made under the rule-of-thumb methods of the housewife must inevitably have often varied widely in composition, and it is to such variations from the right proportions of iron to galls that we must attribute the want of permanency of some relatively modern writings, as compared with that upon manuscripts centuries older.

No more interesting illustration of this effect of composition of ink upon the permanency of writing can be found than in the various names written on the first page of Milton's family Bible, to be seen in the British Museum. It will be noticed that all the entries of the births of himself and the members of his family are in the handwriting of Milton, and that, with one exception, all the inks are of a good dark tone. The exception is seen in the entry of the birth of his daughter Deborah, on "the 2nd of May, being Sunday, somewhat before three of the clock in the morning, 1652." Here the ink has faded to a faint brown color.

Considerable variations are possible in the proportions of iron to gallotannic acid without changing the nature of the resulting black pigment, but if there is a deficiency of tannin outside those limits, insufficient

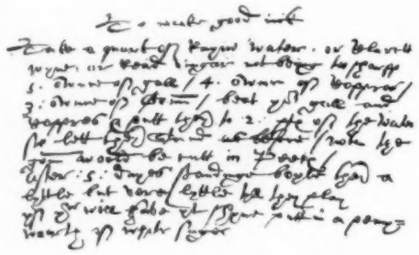


Fig. 1.—Elizabethan Domestic Recipe for Making Ink.

pigment will be formed, and the excess of iron will cause the writing to turn brown. A lack of tannin to combine with all the iron in the ink is probably the explanation of this faded entry in Milton's Bible.

The actual pigment formed when ink dries seems to be the same whether the proportion of tannin to iron be large or small. The writer has made numerous analyses of the deposits produced when solutions of the two substances of varying strength were allowed to stand in contact with the air, and has found them to contain from 5.4 to 6.2 per cent. of iron.

Of the known insoluble iron tannates the one that best corresponds with this proportion of iron is that described by Wittstein (*Jahresb. der Chem.*, 1848, 28,

1898.

1908.

Fig. 2.—Showing the Action of Oxalic Acid on Inks Written in 1898 and 1908.

221) and by Schiff (*Ann. Chem. Pharm.*, 1875, 175, 176) which contains 5.53 per cent of iron, and has the formula:

$$\begin{matrix} Fe\,(C_{14}H_5O_9)_2 \\ | \\ Fe\,(C_{14}H_5O_9)_2 \end{matrix}$$

It is probably this compound that is produced when ink dries on paper, and that the more nearly the proportions of galls and iron-sulphate are calculated to form this tannate without excess of either ingredient, the more permanent will be the writing.

Many of the commercial inks of the present day deviate widely from this standard, and, as everyone must have noticed, the writing done with some of them

1898.

1908.

Fig. 3.—Showing the Action of Acetic Acid (50 per cent) on Inks Written in 1898 and 1908.

will fade considerably, even in the course of a year or two.

Notwithstanding the probably closely similar methods of preparation, the composition of different kinds of ink shows wide variations. Thus, out of twenty-four different varieties of writing ink sold in this country, the writer has found the total amount of solid matter to vary from 1.89 to 7.94 per cent; the ash from 0.42 to 2.52 per cent; and the iron from 0.18 to 1.09 per cent.

Analyses made by the writer at intervals of three or four years have shown that the composition of the products of the same manufacturer shows but little variation. This is only what was to be expected, since, naturally when a satisfactory article has once been obtained, great care is taken to keep it constant by using the same proportions of water, galls, dye-stuff and gum.

In examining writing to ascertain whether it was done with a particular ink, it is advisable to prepare a color scale with that ink, consisting of four washes ranging from the faintest to the darkest possible tone, and to leave this exposed to the air for at least twenty-four hours. The scale may then be compared under the microscope with different parts of the writing in question, and is subsequently used for comparative chemical tests when such are permissible. The broad surfaces of color are comparable with the surfaces of the written characters as seen under the microscope, and there is thus obtained what practically amounts to a magnified record of the microscopical appearance.

Lovibond's tintometer will also be found useful in comparing the colors of different specimens of handwriting, and in matching the colors obtained in chemical reactions with those given by the color scales prepared from known or suspected inks.

In some cases microscopical examination on these lines is sufficient to distinguish between the inks in different writings, without the necessity of applying chemical tests. The most striking instance of this kind within the writer's experience was in the Brinkley poisoning case. The will of an old lady named Blume had been forged by Brinkley, who, on the strength of being her heir, took possession of all the property. Mrs. Blume's relatives contested the validity of the will, and Brinkley had, therefore, to prove that it was genuine. One of the witnesses whose signatures were on the will asserted that he had never signed a will at all, but that he had only signed a folded sheet of paper in a public house. As this witness, Parker, stood in the way, Brinkley attempted to poison him by leaving a bottle of stout containing prussic acid at his lodgings; but, instead of Parker getting the stout, it was drunk by his landlord and landlady, both of whom died. As a great deal depended upon whether Parker were speaking the truth or not, the ink was obtained from the public house in question, and was compared with the writing upon the will.

As the ink happened to contain a particularly bright blue pigment as its provisional coloring matter, there was no difficulty in proving its identity with the ink in the disputed signature on the will. In fact, three different inks were present on this will, the body of the document being written in one kind of ink, and the signatures of each of the witnesses in a different kind. Brinkley, cross-examined upon this point, stated that Mrs. Blue had kept three different sorts of ink, and that he had, after her death, given two of them to a little girl.

After a trial lasting four days he was found guilty of murder, and sentenced to death.

For the differentiation of writing by chemical methods a wide choice of reagents is available, but the following will usually be found sufficient: (1) Hydrochloric acid (5 per cent solution); (2) oxalic acid (5 per cent solution); (3) stannous chloride (10 per cent solution); (4) nascent hydrogen (50 per cent HCl. with zinc); (5) bromine (saturated aqueous solution); (6) bleaching powder (saturated solution); (7) titanous chloride; and (8) potassium ferro-cyanide (5 per cent solution, containing 1 per cent of HCl.).

Of these reagents the first two act mainly upon the iron tannate and leave the provisional coloring matter. The third and fourth bleach the iron tannate and reduce the provisional pigment, changing its color. The fifth and sixth reagents may act upon both pigments and cause more or less bleaching. The titanous chloride acts as a powerful reducing agent on both pigments, and the acidified ferro-cyanide solution acts mainly upon the iron liberated from the iron tannate.

The reagents should be applied with a brush, and the writing examined under the microscope by reflected and transmitted light, firstly after five minutes', and then after twelve hours' exposure to the air. The colorations appearing on the wrong side of the paper are also characteristic in some cases. In the tests with titanous chloride, blotting paper should be applied to the writing after the lapse of five minutes.

The method may be illustrated by the following

* *Knowledge.*

results obtained with some of the best known commercial writing inks.

The question of determining the age of an ink in writing is much more difficult than that of deciding whether two writings are in the same or in a different kind of ink.

It is, as a rule, possible to distinguish colorimetrically between freshly-written and old writing up to about the sixth day, after which the iron tannate has become sufficiently oxidized to prevent further differentiation until after the lapse of two or three years or more, when the provisional pigment will have faded or have become fixed by the iron tannate.

In most cases, the provisional pigments employed, offer greater resistance to the action of chemical reagents, but are infinitely less stable than iron tannate when exposed to the action of light and of air, and eloquent testimony to this difference is given by a comparison of certain manuscripts of the seventh and eighth centuries with type-written documents in aniline ink, which have been put aside for a few years.

Thus it happens that when writing done with blue-black ink is kept, the blue pigment will gradually fade out, leaving the black pigment, and when this stage is reached the ink in old writing is readily distinguished from ink that has recently been put on the paper.

Prior to this, however, the blue provisional coloring matter appears to become enveloped in particles of the oxidized iron tannate, so that it no longer reacts rapidly with reagents.

Thus, if a writing done within the last year or two be treated with a fifty per cent solution of acetic acid there is immediate diffusion of the blue pigment, whereas in a writing a few years older diffusion, if it takes place at all, is very slow and limited in extent (see Fig. 3).

COLORATIONS FIVE MINUTES AFTER APPLYING REAGENTS.

Inks.	Hydrochloric Acid.	Oxalic Acid.	Stannous Chloride.	Nascent Hydrogen.	Bromine.	Titanous Chloride.	Potassium Ferrocyanide.
Blackwood's	bright blue	bright blue	bright blue	deep blue	deep blue	green-blue	bright blue
Draper's ..	deep violet	red-violet	violet	violet	violet-black	maroon	deep violet
Field's ..	deep blue	deep blue	violet-blue	violet	deep blue	navy blue	blue
Mordan's ..	bright blue	bright blue	bright blue	bright blue	dark purple	dark green-gray	dark blue
Stephens' ...	deep blue	deep blue	violet	violet-blue	slight bleaching	nearly black	deep green-blue
Walkden's ..	bright blue	blue	bright blue	blue	blue	gray-blue	dark blue

A still more useful reagent is a saturated solution of oxalic acid, which causes the pigment of relatively fresh writing to give an immediate smudge, but has very little, if any, effect on writing six or eight years old. The differences between the behavior of old and relatively new writing in these tests is seen in Fig. 2, in which the older writing of 1898 was scarcely affected, whereas the writing done in 1908 gave the results shown. Both writings were in ink of the same kind, and the tests were applied simultaneously.

Speaking generally, a writing done with blue-black ink ceases to show such diffusion after about five to six years. When slight diffusion occurs in an older ink it is seen, under the microscope, to differ in character and only to affect the surface of the letters, whereas the diffusion in an ink written within the last two or three years affects the whole of the pigment in the letters.

The first occasion on which chemical evidence as to the age of an ink has been given in the law courts was in the recent forgery case in which Colonel Pilcher was accused of forging his cousin's will.

This will was alleged to have been written in 1898; and assuming this to have been the case the ink should have only reacted very slowly with the different reagents; there should have been little or no diffusion with oxalic acid; and if any slight diffusion occurred this should only have been upon the surface of the letters.

The ink on the will, however, gave an immediate reaction with the different reagents, and diffused at once with oxalic acid, and the diffusion extended throughout the whole of the letters. There was thus no doubt as to the ink upon the will having been written within the last year or two, and certainly within the last six years.

Checks written by the deceased lady during the last thirteen years were also subjected simultaneously to the same tests, and it was found that the ink upon those written in 1903 gave only a faint diffusion with oxalic acid in the heaviest writing, while no diffusion at all was obtained upon the checks written in 1901.

The correctness of the conclusions drawn from these results was borne out by the confession of the prisoner, who, in the middle of his trial, pleaded guilty to having uttered the will knowing it to be a forgery, though he denied all knowledge of how it came to be forged.

Notes on the Economics of Locomotive Operation*

The Problems Presented by Increasing Size

By Prof. Arthur J. Wood

THE locomotive is a power plant on wheels. Every year the demands on this plant are more exacting, and as a result we find to-day the latest type developing over 2,000 horse-power, weighing 445,000 pounds with all the weight on two sets of eight-coupled drivers, with a Walschaert valve gear, compound cylinders, superheaters, and a hydro-pneumatic reversing gear. Contrary to a somewhat common belief, the modern locomotive, if worked to advantage, is an economical machine for what is demanded of it. But the demand for greater hauling capacity has emphasized and enforced the big problem in operation, that of securing the most at the track out of a pound of the fuel burned. Let us briefly note some lines of progress leading to a better economy and to a higher efficiency.

THE THREE BALANCED FORCES.

Let us be reminded that the locomotive is made up of three essential parts—the boiler, the cylinder, and the drivers. In this three-fold combination the boiler power is limited by the amount of steam that can be produced in a boiler of admissible size and weight. The cylinder power may be indefinitely great, but not less than a certain amount, the cylinder being a mere transmitting machine. The tractive power—or pull at the driving wheels—is limited by the total weight of the locomotive and the part of that weight which can be placed on the driving wheels. We have, then, three co-ordinate balanced forces. In practical working, a lack of proper proportion in any one of these three co-ordinate forces which, when combined, make the completed machine, will be shown in the following way: If the boiler power is smallest, the steam pressure will fall and the wheels will stop. If the cylinder power is smallest, the engine will be stalled when using full steam pressure and unable to slip the drivers. If the tractive power is smallest of the three, the engine will slip the drivers. We come to see then that the locomotive is a balanced machine and in any attempt to increase its economy, that balance should be preserved. Thus, if we increase the boiler pressure and capacity, say thirty per cent, everything else remaining the same, the drivers would be slipping some of the time if they were correctly proportioned before.

THE SCOPE OF THE PROBLEM.

It is estimated that 125,000,000 tons of coal (one-fifth of the coal production of the entire country) were burned last year on the 60,600 locomotives in the United States. This coal costs the railroads over $300,000,000. If a net saving of five per cent, otherwise lost, can be secured, this item will be reduced by no less than $15,000,000 and will, at the same time, conserve one of the most valued natural resources of the country. If, further, this saving can be effected by the utilization of low-grade fuels, otherwise discarded, and burned with more nearly smokeless combustion, the results will be far reaching. Possibilities lie along many lines, among which are the following: More perfect combustion, better smoke box and front end construction, by compounding, superheating, and from briquetted fuel. The first two of the above have general application, while the others have given noteworthy results where the conditions were favorable. To these may be added the saving from the introduction of a perfected mechanical stoker, eight or ten of which are being tried out. This saving—estimated on certain roads from ten to fifteen per cent—will come largely from the uncontrolled losses due to improper hand firing.

In a recent analysis of the heat losses in a simple locomotive with superheater running on the test plant at Purdue University, Dr. W. F. M. Goss finds that a little over forty per cent of the heat in the fuel never has a chance to turn water into steam, as shown in the table following:

TABLE I.

AVERAGE HEAT BALANCE FOR TEST LOCOMOTIVE.

(Percentages of total heat available.)

Absorbed by the water in the boiler	52
Absorbed by the steam in the superheater	5
Absorbed by steam in the boiler and the superheater	57
Lost in vaporizing moisture in the coal	5
Lost through the discharge of CO	1
Lost through the high temperature of escaping gases and in the products of combustion	14
Lost through unconsumed fuel in the form of front-end cinders	3
Lost through unconsumed fuel in the form of cinders or sparks passed out of the stack	9
Lost through unconsumed fuel in the ash	4
Lost through radiation, leakage of steam and water, etc.	7
	100

The above suggests the grouping together of some of the various means of securing better results, indicating under each what is being undertaken.

A.—More complete combustion and better firing.	(1) Certain roads, notably the Erie, the C. & N. W. and the B. R. & P., have been giving regular instruction to firemen in the right methods of firing. (2) Adapting the coal to the best conditions of firing.
B.—Saving in losses from stack and front end.	Design of self-cleaning front ends and reduction of losses, as a result partly of exhaustive tests at Altoona.
C.—Adapting locomotive weight to required service and in compounding.	Introduction of the Mallet articulated compound locomotives (with all the weight on drivers) and having two independent sets of coupled drivers for mountain grades, where one locomotive can do the work of two smaller engines.
D.—Reducing high temperature in exhaust gases.	Adapting the Schmidt, Baldwin, Schenectady, Jacobs, Cole, Vaughan-Horsey, and other superheaters.

We may look a little further into these questions.

A. COMBUSTION.

Approximately 544,000 cubic feet of air are required to supply the necessary oxygen to completely burn one ton of coal; less than this means waste in the form of unburned carbon. Not only must the air be supplied, but it must be supplied in the right quantity at the right place. The simple principles of combustion may be studied from the best theoretical furnace on the market—that of the common coal oil or kerosene lamp.

The upper part of the chimney of the lamp corresponds to the stack. The larger part of the chimney is, in the analogy, the combustion chamber including the front end of the locomotive. The small space just above the wick is the fuel bed and the air openings below are the openings through the grates for air supply.

First, remove the chimney, open the hood and light the wick, which should be evenly trimmed. If turned low, it does not smoke. Close the hood and the flame smokes, because the hood has cut off the air about the flame; thus illustrating a furnace with insufficient air where most needed, a condition which occurs when we have too much fuel on the grate.

* *Stevens Indicator.*

Second, place the chimney in its right position on the lamp. The smoke ceases and the flame brightens, showing better combustion. This better condition is from the fact that the draft draws more fresh air about the wick just where demanded.

Third, chill the flame by means of a piece of iron held in it, thus cooling the gases before combustion is complete, illustrating the condition when too much cold air strikes the flame.

Fourth, when burning brightly with the chimney on, shut off the air supply by wrapping a cloth about the hood, closing off the required air supply, and the flame smokes, as it does when the dampers in the fire box are closed too much.

Fifth, break a hole into the side of the chimney or raise it from its seat, and the flame is chilled and the lamp smokes, as we are admitting air where it is not most needed. Open the fire door of the locomotive and the same thing happens, the air being chilled before combustion has been completed.

From these simple experiments, which any reader can make, we learn that the conditions for preventing smoke and securing better fuel economy are:

1. That the fuel be supplied in small quantities and just enough air be passed up through the grates to burn it.

2. That the gases be distilled from the coal at a uniform rate.

3. That the air be heated by passing through the bed of hot coals.

4. That the volatile gases given off shall mix with the fresh supply of air so that each particle of the carbon elements gets its necessary supply of air.

It is understood that smoke comes chiefly in the burning of bituminous coal. The losses in black smoke are not large, scarcely ever exceeding one per cent of the heat in the fuel. A furnace working with a minimum air supply may give out dense clouds of smoke, but still give a higher evaporation than one made smokeless by an excess of air. Consequently smokeless combustion is only an indication of conditions in the fuel bed, and is a very small part of the question of fuel economy. The simple principles of combustion should be well understood by every fireman, and their application be enforced by more systematic instruction. While it is true that locomotives in poor condition are often turned over to the engine crew and they are expected to get results with poor fuel, yet the evil from improper handling of the fuel is by far the greater of the two.

Special Fuels.—The kind of fuel—its chemical composition, its size, friability, ash, and moisture—also influence economy. In one of many results using Lloydell raw coal and the same coal pressed into briquets, being held firmly intact by aid of a "binder" (see Bulletins 412 and 363, U. S. Geological Survey), it will be seen that the briquets gave ten to fifteen per cent higher evaporation than with run-of-mine coal from which the briquets were made. It has been shown that steam can be kept up easier with the briquets, but the disadvantage comes from decreased storage capacity in the tender, difficulty in shoveling, and, last but not least, difficulty in firing.

Road Tests of Briquets.—In co-operation with the Missouri Pacific, the Lake Shore and Michigan Central, the Chicago, Rock Island and Pacific, the Chicago, Burlington and Quincy, and the Chicago and Eastern Illinois railroads, 100 locomotive tests have been made for the United States Geological Survey to determine the value, as a locomotive fuel, of briquets made from a large number of western coals. All tests were made on locomotives in actual service on the road. In some tests there was small opportunity for procuring elaborate data, but in others, where dynamometer cars were employed, it was possible to obtain more detailed results. In nearly every test, the results reported show that the coal, when burned in the form of briquets, gives a higher evaporative efficiency than when burned in the natural state. For example, Indian territory screenings gave a boiler efficiency of 59 per cent, whereas briquets made from the same coal gave an efficiency of 65 to 67 per cent. Decrease in smoke density and in the quantity of cinders and sparks are named as the chief reasons for increased efficiency.

Similar comparative tests in 1907 on the Atlantic Coast Line showed a saving of 20 per cent in the pounds consumed per car mile and with the elimination of black smoke and clinkers. On the W. and L. E. a gain of 16 per cent was secured in ton miles hauled by using three-fourths coal instead of run-of-mine, the former costing 8 per cent more at the mine. Development lies in the direction of making it possible to use to advantage the low grade fuels, and in this the briquets have just begun to open up a new field. The cost of briquetting is roughly $1.25 per long ton.

B. FRONT END LOSSES.

Referring to the table by Prof. Goss, we find that in his tests 12 per cent of the heat of the coal is lost in the front end cinders, and in cinders and sparks passing out of the stack. To correctly design the smoke box, a long series of tests were made three years ago on the Altoona plant with an Atlantic type locomotive of the Pennsylvania Railroad. Approved forms of a self-cleaning front-end arrangement were designed as an outcome of this series of tests. A study of this result compared with the Master Mechanic's front-end design shows a change in the relative proportions of the stack, the exhaust nozzle and the diaphragm plate, the result being much better evaporation in the class of locomotive tested over the same class with the old arrangement in the front end.

C. ADAPTING LOCOMOTIVES TO SERVICE.

Another way of effecting economy in operation lies in adapting the train load and speed to the particular engine best suited to meet the conditions. The most marked advance attracting attention and interest in this particular is in the adoption of the Mallet articulated compound locomotives. An articulated locomotive is one composed of independent cylinder and driving wheel units "tied together at a joint." One example of economy by using an engine of this type is on the Delaware and Hudson Railroad. Four runs were made the past summer with two pushers of the E-5 class, 2-8-0 type, with a total weight 246,500 pounds, 217,500 pounds of which is on the drivers; then four runs with one of the Mallet locomotives having 445,000 pounds on the drivers, followed by four more with another Mallet. The tonnage of all trains were practically the same. The result showed that the Mallet locomotives did almost exactly the same work as the two E-5 engines with a saving of 40 per cent in coal and 27 per cent in water.

D. LOCOMOTIVE SUPERHEATERS.

A superheater is a device whereby additional heat may be applied to the steam after it has been evaporated by the boiler. The advantage comes in (1) reducing or eliminating cylinder condensation, (2) increase of available temperature range of expansion without increase in pressure, and (3) the large increase in steam volume with a comparatively small increase in heat to superheat.

In 1901 the Canadian Pacific introduced the use of superheated steam on locomotives in America and nearly 500 Vaughan-Horsey superheaters are now in service on that road. The Atchison, Topeka and Santa Fe, with 168 locomotives thus equipped, comes second in the list of twenty roads in this country now trying out a total of eight types of superheaters. The Schmidt superheater is used on 130 railroads in Europe, applied to over 5,000 engines. The adoption of superheaters in this country has, on the other hand, been along more conservative lines, notwithstanding the fact that nearly all the roads using them report a material saving in coal and at least half the number find no increase cost in running repairs. The most serious trouble experienced has been in leaky gaskets and filling of front end and flues with cinders.

The question of the amount of superheat is a most important one. The Purdue tests have shown that the first 80 to 100 degrees superheat do not make the same proportional decrease in coal consumption as do the second 80 or 100 degrees. European practice is to superheat until the temperature is 500 to 600 deg. F. or over, in fact, as high as possible and still maintain good lubrication, with forced lubrication for the balanced piston valves. This general practice applies to simple and to compound locomotives; in both cases the attempt appears to be to prevent condensation in the cylinder. This makes an expensive construction to maintain, and it has not met with favor.

Recently tests were run on a tandem compound, 2-8-0 type, of the Atchison, Topeka and Sante Fé Railway, equipped with high and low-pressure superheaters, versus the same class of engines without superheating. Both superheaters are in the front end, the low-pressure superheater being directly ahead of the front flue sheet and the high pressure in front of the low-pressure superheater, both being designed so as not to obstruct the flow of the gases more than necessary. In the following summary the first column gives the results for the locomotive with the superheaters:

Mr. H. B. MacFarland, engineer of tests of the Santa Fe Railroad, has drawn the following conclusions from those made:

1. "There is a marked decrease in coal consumption for a superheater engine. The decrease averages 20.8 per cent per thousand ton miles for up-grade runs, 11.5 per cent for down-grade runs, and 19.6 per cent for constant hard working of engine on heavy grades."

2. "Superheater engine uses 10 per cent less water per hour, developing more drawbar horse-power on heavy working."

3. "Superheater engine with 16.6 per cent less heating surface gives equivalent evaporation of 10.6 per cent more water per square foot heating surface than non-superheater engine."

4. "Superheater engine developed 20 per cent more draw-bar horse-power per square foot of heating surface than non-superheater engine."

TABLE II.

	Superheaters.	Non-superheaters.
Engine Number	901	923
Cylinders, inches	19 and 32 by 32	19 and 32 by 32
Speed M. P. H.	15.7	13.8
Train tonnage	1,339.0	1,189.0
Pounds of coal per thousand ton miles	211.9	275.7
Steam per hour per sq. ft. heating surface	8.57	6.51
Pressure, pounds per square inch :		
Boiler gage	189.0	202.0
High-pressure superheater	182.0	.....
Low-pressure superheater	82.3	.....
Quality of steam per cent :		
At dome	98.9	98.9
High-pressure exhaust	96.9	.....
Superheat degrees Fahrenheit :		
Leaving H. P. superheater	22.6	.....
Leaving L. P. superheater	93.3	.....
Equivalent evaporation from and at 212 degrees Fahrenheit :		
Per sq. ft. heating surface per hour	10.23	7.81
Per pound of coal	8.27	7.08
Indicated horse-power :		
H. P. cylinders	416.0	542.0
L. P. cylinders	846.0	643.0
All cylinders	1,262.0	1,185.0
Boiler horse-power	1,135.0	978.0
Boiler efficiency, per cent	65.9	53.5

Mr. MacFarland informs the writer that the cost of equipping engines with the superheaters used in the tests is $898, of which $750 is for the superheater, $75 for applying the same and $73 for cutting off the flues and setting the flue sheet back. If we assume the cost complete of a locomotive of this type and class as $15,000, the cost of applying superheaters is approximately one-seventeenth of the first cost. The Atchison, Topeka and Santa Fé Railway is having certain engines equipped with low-pressure superheaters only. These will be run in service to determine if this is the most satisfactory arrangement of installation, in order to get for this and others the net economy with front-end superheaters for many conditions.

The study of this question on the Santa Fé is the most important investigation of the superheater equipment for compound locomotives undertaken in this country. Assuming 450 deg. F. as the maximum temperature allowable in the steam chest, the present development as being worked out is much more attractive than any of the methods requiring excessively high temperatures.

From the data given, the writer has plotted a temperature-entropy diagram. To any not familiar with this diagram it may be stated the areas represent heat units expressed in B. t. u. In the original of this particular diagram, 1 square inch equals 10 B. t. u. Knowing the number of B. t. u. in a unit area we may readily determine the heat change represented along any line. This is all we need to know to understand its application to the problem in hand.

Fifty-eight and sixty-one-hundredths B. t. u. per pound of steam equals work done in high-pressure cylinder, which is less than one-half of the amount of work done in the low-pressure cylinder. The same fact is shown from the horse-power results given in Table II. The work could have been more equally divided by changing the cut-off in the low-pressure cylinder. In stationary practice it is common to divide the temperature range equally between the high and the low. This would have given a better distribution in the case at hand.

We conclude (1) that a small amount of superheating in the high-pressure cylinder is of little or no advantage, (2) when the pressure drop is large between the cylinders large gain is effected by a considerable superheat in the low-pressure cylinder, (3) for the same amount of heat in the superheat (in the case considered), we could theoretically gain less in heat transformed into work by using the two superheaters than we could by the same amount of heat in one high-pressure superheater, but this requires the objectionable high superheat, and (4) superheating to 100 degrees or over for the low-pressure cylinder is, theoretically, an attractive proposition, the practical results of which will be learned later with interest.

It must be understood that actual conditions on a locomotive will not correspond exactly with the conditions which have been taken in this study. For example, the writer has assumed adiabatic expansion. Actually, it is modified by cylinder condensation, but since it was considered the same in all cases the results may fairly be compared in the way outlined.

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